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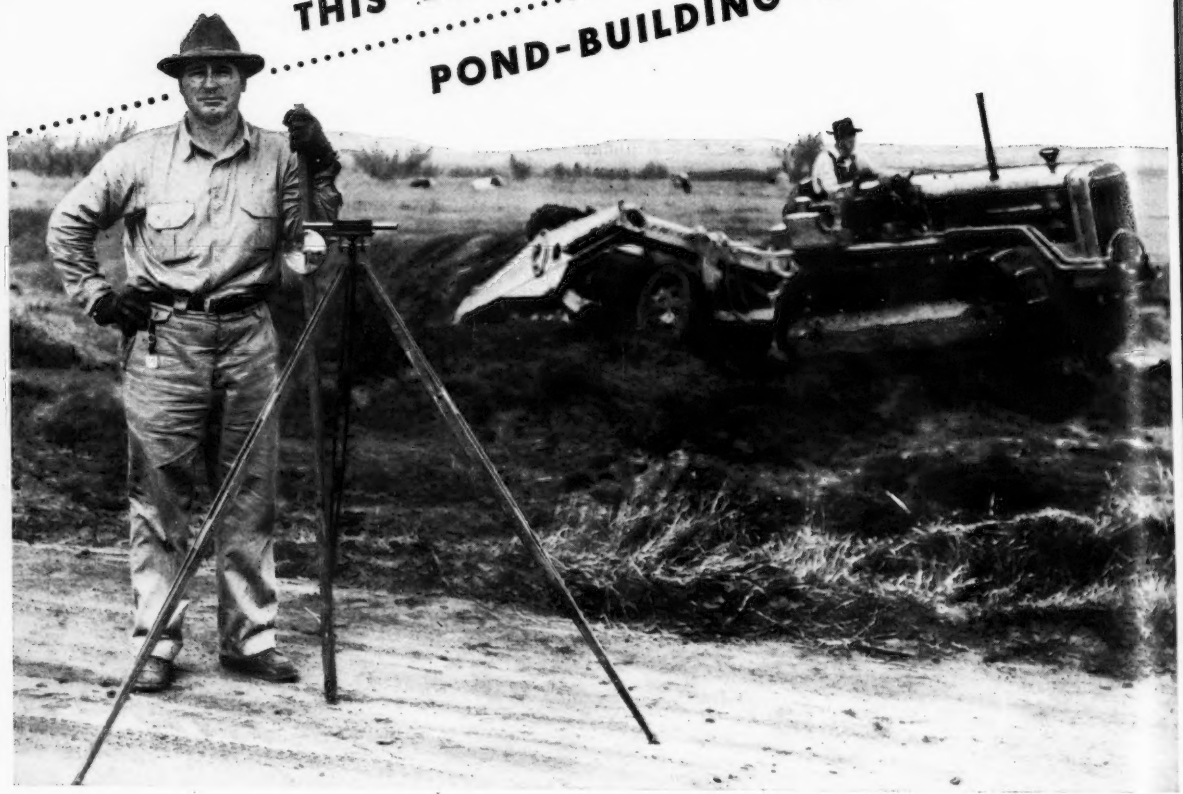
THIS ENGINEER IS A POND-BUILDING CONTRACTOR!



FOR several years, Graduate Engineer Leebert Johnson, Conway, Kansas, has been a pond-building contractor. His "Caterpillar" Diesel D4 Tractor and carry-type scraper commonly move 500 to 700 cubic yards of earth per 10-hour day.

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EDITORIAL

Electricity to Earn Its Way

WE HOPE that the slightly forbidding phrase "electro-economy" used by D. W. Teare will not keep any reader from giving serious attention to his A.S.A.E. annual meeting paper appearing as the leading article in these pages. Though he sets it forth modestly enough as a theory, he has set up a way of approaching rural electrification which promises to be sound in practice, however great may be the revision of detail to suit specific situations.

Mr. Teare is realistic in recognizing that the major force in making farmers *want* electricity is its contribution to personal comfort and convenience. He goes beyond the purveyors of electric energy and equipment, in their usual sales methods, by deliberately searching for economic uses for electricity which will justify farmers in having what they want. If farm electricity does no more than make "one hand wash the other" it still will be eminently worth while.

However, we admit no such limitation. We shall not be satisfied until the productive uses of electricity in agriculture so far eclipse its household applications that the latter will be a minor by-product. Until such preponderance is attained, the agricultural engineers in farm electricity have only started their job.

In particular, we rather resent the custom of estimating potential load in terms of farmsteads per mile of line. Under that concept the richest territory is one of minimum-sized farms, of families closest to the subsistence level. When farm electrification really arrives, potential loads will be computed in terms of productivity per square mile. It will be the number of cows to be milked, the number of bushels of grain to grind, the acreage of crops worth watering, which carry the key to kwhr, not the number of dwellings.

Meanwhile, pending approach to that goal, Mr. Teare's proposal may well form the basis for faster, sounder extension of rural electricity.

Discount the Depression

NOT TOO little and too late, but rather too late and therefore too much, seems to be our habit in making economic adjustments. In reminiscent review we see the postwar boom of 1919, the agricultural collapse of 1920-21, the speculative orgy of the late 1920's, and the slow, reluctant sobering up of the 1930's. Every one of those abnormalities might have been mitigated by a little more realism in appraising the present, a little more vision into the future.

With all these economic and emotional blunders still fresh in memory, it should be possible to minimize the degree, if not to forestall the fact, of their repetition in the impending postlude of war. In our humble opinion the impact of reconversion and contraction for peace can be greatly softened by anticipating adjustments, making them early and moderately rather than waiting for the full fury of forced acceptance.

To be sure, the problem is much wider than agricultural engineering or even of agriculture, but we still can exert our influence in the general situation, and may well bear in mind that our influence is greater than our numbers. As a profession we have a special stake in the postwar changes. Reconstruction of the farm building plant, re-equipment with power and machinery, renewed energy in soil conservation, indeed every objective of our profession for our clientele, all demand early and orderly adjustment rather than demoralizing deflation and years of delay.

We suggest a deliberate policy of immediate but moderate reduction of all prices and wages, agricultural as well as industrial, which have advanced as a result of war conditions and pressures. In particular, we should work toward prewar balance or ratios among prices and wages. We do not regard those ratios as altogether equitable, but we believe we can make faster and safer progress by using them as a starting point than by trying to prolong the fictitious and still more inequitable ratios of the war economy.

Emphasize Education

IN ALL the clamor concerning adjustment for peace there has been too much talk about jobs, not enough about education. Both as a temporary cushion and as a permanent preparation for perpetuating the American way of wholesome living, education holds more promise than any other single thing.

Nearly a whole college generation will have been diverted into the armed forces. With them should be counted the boys and girls who have left high school prematurely to take jobs for which they are all too ill-qualified. To think that they all can be thrust immediately into peacetime employment with any solvency is obviously fantastic. Equally obvious, so great an infusion of inadequately educated young people into the social and political scene would greatly weaken our capacity as a nation to cope with the tremendous problems that lie ahead.

We challenge the doctrine that every soldier discharged and every factory hand laid off should be found a job. Instead, the traditional age brackets for school and college should be extended at least four years to give them the education they should have for a lifetime of productive employment and sound citizenship. To the extent that they may be deemed deserving wards of the state, it will be little more costly and certainly less debasing to put them into school than to put them on WPA, by whatever euphemism it may be known.

By whatever number the schools and colleges can absorb, the number of jobs remaining for older people will be greater. Both groups will be in constructive, self-respecting activity. Yet it would be a mistake to set an age limit, even a new and higher age limit, on education. In both public policy and public opinion we must make increasing place for adult education.

In times past, the average life span was shorter than it has become now. At the same time, technological advance was slower. A man who prepared in his youth for a trade or profession was equipped for life. Already we have reached the point where many men outlive their educations. In the learned professions the sabbatical year and the refresher course are accepted. We must extend the principle and practice of re-education to other occupations. We should push it with all haste now as a measure of reconversion.

As agricultural engineers we have a special obligation to promote such educational programs. We are lifting agriculture to levels which call for better educated farmers. We also are lowering the number of people needed to produce the nation's food and fiber. We must do all in our power to see that agriculture's surplus man power is trained to take its place in other occupations. *(Continued on page 348)*

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AGRICULTURAL ENGINEERING

VOL. 25 SEPTEMBER 1944 No. 9

An Electro-Economy for Agriculture

By D. W. Teare

MEMBER A.S.A.E.

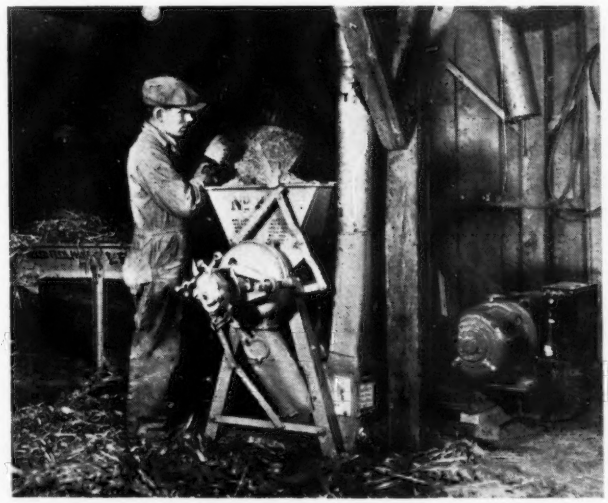
THE nation-wide rural electrification program has increased the percentage of farms receiving central station service from 10 per cent in 1935 to approximately 40 per cent at present. This activity on the part of farmer-owned cooperatives and the utility companies is a major development without parallel in agricultural history. It is especially interesting to note that the distribution of power has already reached every kind and class of farmer. The desire for lights is universal among all farm people and the extent of past construction programs has fully convinced most unserved farmers that, had Hitler and Tojo not intervened, they would now have lights. It is highly probable that many war bonds are being earmarked to pay the cost of electrification and to buy electrical equipment. The demand for service by the entire agricultural population is a phenomenon not previously encountered in extensive agricultural developments.

In the case of power farming, it took thirty years to adapt the tractor to all types of farming so that a universal market existed. The combined harvester-thresher went through a similar period requiring farmer education, machine adaptation and even the tedious process of plant breeding to develop suitable characteristics in crops so they could be successfully harvested with a combine. In contrast, the entire farm family is intensely interested in electric power and equipment because each of them is offered highly desired improvements in daily living. Unfortunately the rural conception of farm electrification is climaxed by the desire for lighting rather than the productive applications of power. It is said that the Chinese greet each other by asking "Have you eaten rice?" In rural America, a frequent salutation is "When do you expect to get lights?"

In many communities events are dated as having occurred before or after "lights" were turned on. The energization of rural lines is indeed a red letter day in the lives of whole communities. The shortage of farm labor, the discontinuation of line construction because of the war, and the scarcity of electrical equipment are negative educational influences concentrating the farmers' attention on the possibilities of electric power in labor saving and lower cost production, yet farmers who have had electric power for many years have not gone much, if any, beyond the urban dweller in putting electricity to work. Although lights, radios, irons and refrigerators have reached a high saturation point on the older lines, the use of productive equipment has not approached even a good beginning except on some dairy, commercial vegetable and poultry farms.

The feasibility of rural line construction has been based on population density rather than on the possibility of extensive use of power and a high average consumption by the farmers. With densities of 2.5 farms to the mile or more, it is reasonable to believe that the natural, though slow, growth of electric use will eventually liquidate the costs of distribution lines serving such populous communities. The widespread farmer demand for "lights" and the probable postwar pressure for work projects to employ returned soldiers make it entirely possible that the extensions of lines in the postwar period may be so rapid that farms will be served long before the potential consumers would normally be able to use the power extensively. This might be particularly serious from a financial viewpoint because many of the unserved communities consist of thinly settled or submarginal areas where revenue per mile on the present basis of load building will, for a long period, be too low to justify the line construction cost. It is granted that the social need of such communities for power is as great as any other, but the extensive electrification of such areas may seriously jeopardize the economy of both individuals and the community if expenditure of capital reserves for non-productive equipment is followed by high monthly power bills. Farmers have not hesitated to drop telephone service in the past and can be expected to turn off electric power and let payments on uneconomic equipment lapse in the future, if they suffer financial limitations. A wide break in farm prices would probably bring serious financial difficulties if not catastrophe to the backers of rural lines and their consumers if they have based their farm electrification on the city plan of comfort and convenience instead of production.

While power lines have been extended to many farms, there are, from the agricultural engineer's viewpoint, few really electrified farms. In searching for the causes of the slow development in extensive use of farm power, the author is fully convinced that use of power in comparatively large quantities will develop only when electricity becomes an economic tool that will produce additional farm revenue sufficient to liquidate and maintain electrification costs. With this idea as a foundation, the author has developed the theory of an "Electro-Economy for Agriculture". Such an economy may be defined as the application of electric power to farm problems for the purpose of increasing and maintaining farm income in cash or in kind sufficiently to pay for the cost of needed and desired equipment and to provide monthly revenues for payment of the power bill and additional equipment installments. Electro-economy applications are not substitutes for recognized technical and management practices but rather catalytic agents which promote and effectuate desired results when better methods are used.



On every farm adapting electric power into the farm business, there is a definite conflict in the use of electric power between the cash income on one side and the cost of equipment and the monthly bill on the other. In studying farm incomes of the various agricultural regions, for the between-wars era, the generalized information in Table 1

TABLE 1. AVERAGE ANNUAL FARM INCOME IN CASH

Cotton belt	$ 350.00
Great plains	700.00
Corn belt	1250.00
Regional average	650.00

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis., June, 1944, as a contribution of the Rural Electric Division.

D. W. TEARE is head, farm electrification unit, Rural Electrification Administration, U. S. Department of Agriculture.

was assembled. These cash returns are startlingly low especially in view of the present wartime prices and much higher farm incomes. However, it may be assumed that, if the operation delineated herein can be successful at low prices, they will be even more successful if present prices maintain. In comparing these incomes with urban wages, it is easy to see that rural sales campaigns will have to be based on income production rather than personal desires for luxury, comfort and convenience.

Table 2 is a comparative study in the cost of electric equipment, frequently recommended for establishing an electrified farm and the average cash farm income. It will be noted that this equipment is typically household equipment. It is significant that most rural sales programs by both manufacturers and rural line operators have concentrated on this expensive, high consumption and, with the exception of the pump and refrigerator, non-productive equipment.

TABLE 2. PERCENTAGE CASH FARM INCOME REQUIRED TO PURCHASE THE SPECIFIED ELECTRICAL EQUIPMENT

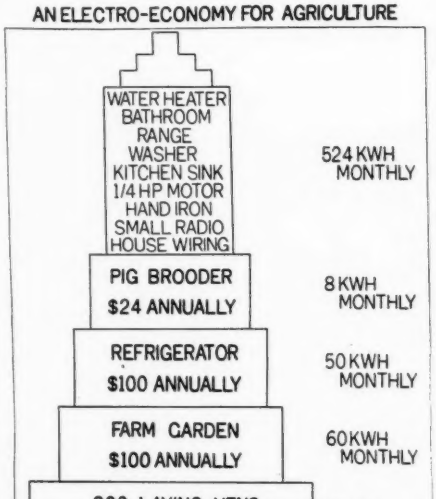
Regional Average Farm Cash Income, $650.00

	Cost of Equipment	Per cent of annual Income
Wiring for service	$125.00	19.2
Annual minimum bill at $3.50 per month for 40 kwhr	42.00	4.6
Radio and iron	30.00	4.6
Washing machine	75.00	11.5
Shallow-well pump and sink	75.00	11.5
Range	135.00	20.7
Refrigerator, 8 cu ft	150.00	23.1
Water heater	75.00	11.5
Bathroom equipment	300.00	46.1
Annual electric bill to operate above equipment	152.40	21.9
Total	$1,117.40	170.1

Prices and income quoted are prewar since present farm income is abnormally high and electric equipment practically unavailable. Few salaried people would be willing to pay such high percentages of their annual income to enjoy the benefits of electric power. The farmers as a group have not been willing to spend 11.5 per cent of a year's cash supply for a water pump and sink, 20.7 per cent for an electric range, 11.5 per cent for a water heater, 46.1 per cent for modern bathroom installations nor 21.9 per cent for the power bill just to operate the equipment as is evidenced by the uniformly low average power consumption. This last figure on annual power cost explains why farmers on the Garner project at Garner, Iowa, in the 1920's and other farmers on numerous electrified demonstration farms since have not bought equipment installed and successfully operated during a demonstration period, even when it was later offered for sale at greatly reduced prices.

Farmers may not have analyzed the economic causes of their inability to use electric power, but few to date have permitted their own or their families desires to carry them into excessive electrification for which they cannot pay. If electricity is to take its proper place in agriculture, the farmer must be taught the economic possibilities of electric power. Such training should include the methods of increasing production, improving the quality of products, timely production, preservation of perishable products, complete or partial processing of raw products, an improvement in the technique of insect and germicidal control, and in labor-saving installations.

As previously stated, dairy farmers, commercial vegetable producers, and poultry farmers have been quick to utilize the opportunities of high-line service to reduce costs, improve the quality of marketable produce and save labor. On the other hand, thousands of farmers who have electric power do not produce such products in quantity and see no opportunity to use electricity productively. This is especially true of the southern farmer, the small grain producer and farmers with small acreage everywhere.



The peculiar situation in which 85 per cent of the farmers are reported to receive only 15 per cent of the cash farm income offers a splendid opportunity to use electric power to promote subsistence living of a high standard. To meet the need of all types, classes and sizes of farms ranging from 5 to 5,000 acres, the following five-year program based upon an electro-economy foundation is suggested. It utilizes the "subsistence" production methods long advocated as essential to successful farm living. It is believed that by following this or a similar plan all farm families can acquire and continuously operate sufficient electric equipment to establish the following objectives as a national reality:

1 Establish electric power as an economic tool that will increase farm revenues sufficiently to pay for the power and the equipment needed to operate an electrified farm.

2 Raise the existing farm living standard to a much higher level.

3 Increase the average power consumption sufficiently to make the electrification of the remaining unserved but thinly settled and submarginal areas feasible.

4 Lay the foundation for the development of rural industry to insure occupation of surplus farm labor in normal times.

A FIVE-YEAR ELECTRIFICATION PROGRAM FOR AN INDIVIDUAL FARM

The purpose of outlining a five-year financing and equipment acquisition program in detail is to assist the new farm user of electric power in acquiring and continuously using a maximum amount of electric equipment in his daily life and in his farm business by making productive equipment immediately effective and additional income thereby available.

In order to classify a farm as electrified, the author is of the opinion that an average consumption of 200 kwhr per month should be used with at least two productive applications of power. On such a farm it is probable that at least $1,000 would be invested in electrical equipment and a power bill of $10 monthly or more would have to be met. The equipment acquisition plan as outlined in Table 2 to Table 4 is based on the present federal requirements that, with certain exceptions, equipment purchased on the time-payment plan must be paid for in one year with a 20 per cent down payment made at the time of purchase. The only exception in this plan is the water pump which can be paid out in 60 months and requires a 10 per cent down payment. In general, sufficient productive equipment should be started the first year to liquidate all monthly cash expenditures for power and installment payments.

TABLE 3. CAPITAL REQUIRED TO START A FIVE-YEAR FARM ELECTRIFICATION PROGRAM

First six months electric bill	$52.26
Down payments on first year appliances and supplies	52.04
First six months equipment installments	83.28
250 chicks at 12c each	30.00
Feed for chicks	80.00
Interest on capital invested for 6 months	8.92
Total	$306.50

Under present regulations a capital investment of approximately $310.00 is considered essential to start an electrification program on a basis that will have a strong probability of success. This capital may be obtained from individual reserves, or borrowed from local financing agencies. The amounts and the proposed allotment of this starting capital are shown in Table 3. The money allotted to six monthly electric bills, installment payments and interest on borrowed capital is required while production and income are being established. When normal conditions return and equipment installments can be extended from 36 to 60 months with only 10 per cent down payments required, the capital necessary to start such a program would probably not exceed $250. Both productive and non-productive electric equipment are included in this plan. In order for a farm family to have the maximum com-

forts of non-productive equipment, it is essential that productive equipment be quickly acquired to establish an income to provide the funds to pay for and operate the various devices.

There are many revenue-producing applications which can be operated on specialized farms. In most cases operators of specialized farms are forced by law or trade competition to install such equipment in order to stay in business. This plan may be incorporated into such farm businesses but it should be understood that the real problem in developing rural electrification is with the lower-income, single-crop or non-specializing farmer for whom this particular plan is suggested. Such farm families are the ones who use the farm as a way of life, whose living standards are lower than most urban families, and where malnutrition and deficiency diseases are common. Electricity offers these people an especially attractive and practical opportunity to improve their lot in life.

Four methods of income production are employed using six applications of power to produce income in cash or in kind that will be sufficiently large to support an extensive electrification program.

1 Poultry production applications—yearly income $200.00
   (a) Night lighting for 200 layers
   (b) Water warmer, submersion type
   (c) Electric brooder, 250 to 300-chick size

2 Garden watering equipment—yearly income 100.00
   (a) Deep or shallow well pump of 300 gph capacity
   (b) Supplementary watering during the dry summer months

3 Refrigeration, household type—yearly income 100.00
   (a) 6 to 8 cu ft capacity
   (b) Saves food, keeps cream sweet and eggs fresh

4 Pig brooders, yearly income 24.00

Referring to the chart accompanying this paper, it will be noted that these four productive fields for electric applications support all of the listed household equipment which is classified as non-productive, even though it may save time and labor. These applications will, with ordinary skill and attention, increase farm income in cash or in kind sufficiently to produce an estimated minimum return of $424.00 annually as shown. The average monthly power consumption of the productive equipment totals 183 kwhr which, properly handled, will support the additional consumption of 524 kwhr per month as well as accumulating the funds that will pay the cost of the equipment listed. If this plan were carried out as shown, a total of 707 kwhr per month would be consumed, a monthly power bill of $19.24 would be successfully met, and additional revenue would accumulate yearly depending upon the equipment acquired and the current consumed.

Using the productive equipment as extensively as possible the first year insures rapid extension of electrical applications. There are many other productive applications of electric power, but the four selected are recommended as the foundation of the program because they are applicable on any type or size of farm and in any section of the country with a minimum of effort and expense. It makes little difference whether the individual making these electrical applications has already been a producer of such farm products or not, in so far as additional returns are concerned. If he is a beginner in such productive applications, electricity will enable him to overcome many of the hazards of inexperience and thereby show the estimated net return over costs. If he has already established such production, electric applications will, because of improved methods and technique, enable him to make additional profits to the extent estimated on the production capacity recommended. Additional profits are proportional to the applicant's experience, skill, ability, and the extent to which he produces. The amounts of production recommended are for the beginner with limitations in capital, acreage, experience and time. It is not thought that every new user of electric power will follow the routine of application and equipment acquisition exactly as recommended in Table 4, because each individual farm family will make applications in accordance with their needs, desires and opportunities to use power productively.

First-Year Acquisitions. (See Table 4). On the majority of farms the house is wired and a radio and iron are purchased immediately when the power is available. Other buildings are wired and equipment purchased much less frequently. Consequently in making up the five-year equipment acquisition schedule in Table 4, these popular household items were included in the first year's installation. The establishment of a poultry flock with 250 chicks to start is also included because poultry offers the quickest and surest returns on productive electrical applications. If poultry to the extent of 200 laying hens are already kept, the applications would be made to the existing flock or it could be increased as

TABLE 4. AN ELECTRO-ECONOMY FOR AGRICULTURE
Prepared by D. W. Teare, April 5, 1944

Column	1	2	3	4	5	6	7	8	9	10	11
Applications	Monthly unit estimate	Monthly kwhr total	Monthly bill	Cost or sales price	Down payment	Monthly installments	Total appliance investment	Monthly income	Total Monthly cost	Monthly net	Accruals
FIRST-YEAR ACQUISITIONS											
Housewiring	30	30		$100.00	$20.00	$6.87	$100.00		$10.37		
(a) Radio	10	40	$3.50	25.00	5.00	1.72	125.00		12.09		
(b) Iron	5	45	3.75	6.00	1.20	.41	161.00		12.75		
Poultry house wiring											
Lighting (180 kwhr yr)	15	60	4.50	25.00	5.00	1.72	156.00		15.22		
Brooder (500 kwhr yr)	41⅔	101⅔	6.15	7.00	1.40	.48	163.00		17.35		
Water warmer (100 kwhr)	8⅓	110	6.40	3.60	.72	.25	166.60		17.85		
Chickens, 250 at 12c				30.00	30.00			16.66			
Feed for chicks				80.00	80.00						
Portable motor	5	115	6.55	15.00	3.00	1.03	181.60		19.03		
Pig brooder	12	127	6.91	3.50	.72	.25	185.10	2.00	19.64		
*350 gal pump and kitchen sink	60	187	8.71	75.00	15.00	1.15	260.10	8.33	22.59		
Totals, first year		187	8.71	370.10	162.04	13.88	260.10	26.99	22.59	4.40	52.80
SECOND-YEAR ACQUISITIONS											
First-year carry-over		187	8.71			1.15	260.10	26.99			52.80
Refrigerator, 8 cu ft	50	237	9.84	160.00	32.00	10.98	420.10	35.32	21.97		
Washing machine	5	242	9.94	75.00	15.00	5.15	495.10	35.32	27.22		
Dehydrator	25	267	10.44	15.00	3.00	1.03	510.10	35.32	28.75	6.57	78.84
Totals, second year		267	10.44		50.00	18.31	510.10	35.32	28.75	6.57	81.64
THIRD-YEAR ACQUISITIONS											
Second-year carry-over		267	10.44			1.15	510.10	35.32			81.64
Electric range	125	392	12.94	135.00	27.00	9.27	645.10	35.32	23.36	11.96	198.16
Totals, third year		392	12.94		27.00	10.42	645.10	35.32	23.36	11.96	198.16
FOURTH-YEAR ACQUISITIONS											
Third-year carry-over		392	12.94			1.15	645.10	35.32			198.16
Bathroom	15	407	13.24	300.00	60.00	20.60	945.10	35.32	34.99	.33	142.12
Totals, fourth year		407	13.24		60.00	21.75	945.10	35.32	34.99	.33	142.12
FIFTH-YEAR ACQUISITIONS											
Fourth-year carryover		407	13.24			1.15	945.10	35.32			142.12
Water heater	300	707	19.24	75.00	15.00	5.15	1020.10	35.32	25.54	9.78	244.48
Totals, fifth year		707	19.24		15.00	6.30	1020.10	35.32	25.54	9.78	244.48

Rate: 40 kwhr.....$3.50 120 kwhr..... 3.60
40 kwhr..... 2.00 All over at 2c

*Calculations on pump and sink are made on the basis of a 20 per cent down payment and installments over a 60-month period.

desired. Five hundred chickens should be raised yearly in two successive broods using a 250 to 300-chick brooder, homemade in this instance, which will consume approximately 500 kwhr for the year. Night lights and the water warmer should be used in the fall and winter to insure profitable egg production and a labor income of at least $1.00 per bird. Another advantage of the poultry program is that once established it provides a regular monthly income necessary for monthly power bills and equipment installment payments.

A fractional horsepower portable motor is included for changing hand-powered tools and equipment to power drive. This is a labor-saving application enabling the beginner to enjoy many of the benfits of electric power without greatly increasing his investment in power equipment. Few farms wish to dispose of good hand-powered equipment before it is worn out, even when electric equipment is available. The psychological effect of immediately starting a farmer to using power as soon as it is available is highly desirable. When converted hand-powered equipment is worn out, the average operator can be expected to purchase electrified models if available, especially if he has become accustomed to depending on power.

A homemade pig brooder is particularly desirable because it is so effective in obtaining immediate results and at the same time is simple to construct and operate. It fills an immediate need recognized by every farmer producing pigs north of Texas. A saving of 20 per cent of the pigs brooded, through prevention of chilling and crushing, is a common result. Since pork is one of the cash income sources or home-consumed products of most farms, a 20 per cent saving in pigs lost is definitely an effective and desirable method of increasing farm income.

Last, but far from least, an automatic pressure system with a 350-gph pump and a kitchen sink are included for immediate use of the family. These are triple-purpose devices in that they immediately raise the standard of living, reduce labor requirements tremendously, and definitely increase production. In the barnyard, a constant water supply is effective in improving livestock health, increasing growth, and increasing milk production. Its greatest income possibility is through increased garden production by making supplementary watering of a $\frac{1}{8}$ to $\frac{1}{4}$-acre farm garden easily possible.

The U. S. Census for 1935 shows a farm garden production evaluation of only $29.00 per farm for the entire United States. It is probable that this low evaluation is due to limited production primarily caused by short, intensely dry spells, which greatly reduce if not completely ruin garden yields. A 350-gph automatic pressure pump makes it easily posible to put one inch of water per week on gardens of limited size when wells or other adequate sources of water supply are available. Experimental records indicate that yields of gardens and quality of vegetables so watered increase from one hundred to several hundred per cent. Any family with a supply of fresh vegetables of high quality in any community has a ready cash market either on their own table or in the immediate neighborhood.

Summarizing the results of the first year's proposed applications, the following should be noted in first year totals, Table 4:

1 A 187-kwhr per month load could be built (Column 2)

2 A monthly power bill of $8.71 would have to be met (Column 3)

3 $260.10 worth of electrical house wiring and equipment could have been purchased and all paid for except the last four years' installments on the pump and sink (Column 7)

4 A monthly income of $26.99 could have been established (Column 8)

5 A monthly expenditure for power and installments amounting to $22.59 could have been developed and successfully met as indicated in the following item (Column 9)

6 A monthly net of $4.40 per month throughout the first year could have accumulated $52.80 to take care of interest on the starting capital, to make a payment on the principal of a capital loan or other expenses that might arise (Columns 10 and 11).

Second-Year Acquisitions. It should be noted that a refrigerator was not included in the first-year purchases. This is primarily due to the comparatively high cost of an 8-cu-ft box and the limitations of capital on the average farm. Since a refrigerator is productive equipment, any family with sufficient capital would be justified in purchasing the refrigerator the first year. It is also possible that a family might wish to have a refrigerator before they have running water in the kitchen and, if so, the refrigerator could be purchased the first year, although some additional capital would be required for starting the program. When this change is made, the pump and sink could be left until the second year for installations. In this plan the refrigerator is the first item of the second-year purchases. In Column 11, Table 4, it will be seen that $52.80 had accrued at the end of the first year. This money is used to make the down payments on the second-year purchases. Of this fund, $32.00 would be paid down on a refrigerator, $15.00 on a washing machine and $3.00 on a dehydrator of homebuilt design and construction. The refrigerator is primarily productive equipment and estimated yearly savings and earnings total $100.00. Cash earnings are realized from higher quality eggs, cream and vegetables or fruits marketed locally. This device completes the productive equipment required for this five-year plan. Earnings of the six applications, namely, poultry lighting, water warmer, chicken brooding, pig brooding, running water and refrigerator (which totals $424.00 annually) amounts to $35.33 monthly. This comparatively small monthly income is sufficient to complete successfully the five-year program as outlined.

In reviewing the results of the second year's proposed program, the following should be noted in the second-year totals of Table 4:

1 A 267-kwhr load could be built (Column 2)

2 A monthly power bill of $10.44 must now be met (Column 3)

3 $510.10 worth of electrical house wiring and electrical equipment could have been purchased and all paid for except the last three years' installments on the pump and sink (Column 7)

4 A monthly income of $35.32 could have been built (Column 8)

5 Monthly expenditures for power and installments total $28.75 (Column 9)

6 A monthly net revenue of $6.57 throughout the second year could have accumulated $81.64. Again this money could be used for down payments on additional equipment or for other purposes (Columns 10 and 11).

Third, Fourth and Fifth Year Acquisitions. At the beginning of the third year, the electro-economy program should be so well developed that comparatively expensive, high-power consuming devices with little if any productive value could be financed. Such items would include the electric range, the complete bathroom and an automatic electric water heater. These appliances may be purchased in whatever order is desired and within any period of time necessary to accumulate the necessary funds. In this program the equipment is to be purchased in the above order at one-year intervals. This permits the accumulation of sufficient surplus earnings to make the down payments on the bathroom in the fourth year. Incidentally, a complete bathroom including a proportionate share of the water pump and hot water heater amounts to 40 per cent of the total investment in equipment on this program. This explains, first, why few farm families now have bathroom installations and, second, why its installation is delayed until the fourth year in this program.

At the completion of a successful five-year electro-economy program the following results could easily be reached as shown in the fifth year totals of Table 4:

1 A 707-kwhr per month load could have been built (Column 2)

2 A monthly power bill of $19.24 or more would have to be met (Column 3)

3 $1,020.10 worth of electrical equipment could have been purchased and paid for (Column 7)

4 A monthly income of $35.32 could have been built and maintained (Column 8)

5 A monthly power bill of $19.24 could be maintained indefinitely with a net revenue of $16.08 for other use (Column 3)

6 $244.48 over and above all electrification costs could have accrued by the end of the fifth year (Column 11)

These accruals would have permitted a more rapid liquidation of equipment costs in the third, fourth and fifth years of the program, indicating that the five-year program is a conservative plan allowing for unforseen conditions that might reduce revenues considerably.

The Self-Propelled Combine

By Joe Tucker

THE present best-known example of a self-propelled farm machine is the self-propelled combine, and it is my opinion that the tractor-pulled, engine-operated large combine is doomed to practical extinction as soon as open competition comes back. Why? Because the self-propelled machine will do more work with less labor and at less cost. There are other reasons too, but the postwar farm labor situation, with less and more expensive help, will alone compel the adoption of the one-man combine.

Yes, the first cost will be higher, and the farmer will need a tractor anyway. But this industry has thrived these past 20 years by replacing less expensive horses with more expensive tractors and by replacing one thresher with three or four combines — and for exactly the same reason, i.e., to do more work with less labor and therefore at less cost.

The self-propelled combine has four distinct advantages over the ordinary large engine-driven machine:

1 One man operates it — both faster and better. He decides where he will go and, within the limits of its speed range, how fast or how slowly, determined by condition of land and crop. He can run cater-cornered across fields, making shortened driveways for the grain trucks; he can run around green spots; he can come right back alongside his last cut, and he is never at the mercy of a sleepy, day-dreaming tractor driver who doesn't know the combine is plugging up with weeds or heavy down grain until the machine is plugged tight.

2 No tractor is used, thereby saving man power, fuel, and repair parts. Fuel consumption is greater, of course, in the self-propelled than in the pull type machine of the same size, but very little greater. Actually, combine engines run much of their time at light loads — they need reserve power to take care of the occasional slug, and these slugs come far less frequently when the operator himself constantly sees and easily controls both speed and feed of his machine. The real saving in fuel comes from elimination of the tractor. The tractor can also be used for other necessary work, and there is usually plenty of it at harvest time.

3 Both grain and time is saved in opening fields. Time is also saved in getting ready to move in or move out. The ordinary tractor and combine, with the cutting table to the right side of the machine, will roll down and practically destroy an 8-ft swath of grain while opening a field. An 8-ft swath around an 80-acre field takes in two acres. At a yield of 20 bu per acre, grain is wasted to the extent of ½ bu for every acre in the field. In smaller fields or heavier yields, the loss is greater; in larger or light yielding fields it is less. In irrigated fields of heavy grain, the loss is terrific. In fact, many self-propelled combines are used in California and the Northwest only to open up fields and pay for themselves in one season by the grain saved which would otherwise be lost.

4 They have great flexibility, thus saving both grain and time. Frequently we find wet swales in fields filled with unripe grain. It is easy to run around such a spot and come back in a few days to harvest the grain there when it is ripe. Many fields in the old "dust bowl" area are planted with listers or deep-furrow drills, both leaving high ridges which are extremely difficult to navigate in any direction but lengthwise. Here the self-propelled combine can turn around and come back cutting a swath right next to where it has been cutting — a great saving in time and comfort for the operator.

Because of these advantages, the self-propelled combine will make the large engine-driven machines obsolete. It is of course probable that the smaller power take-off combine will also replace some of the large ones, so the self-propelled machine will not have the field to itself. But it will provide a much better competitor for the small machine than would the large engine-driven type.

There are only 109,000 combines with a cut of 10 ft or over on all the farms of this country, with an average age of 9 years. The best year's sale of this size in the past ten years has been only a meager 6,000 machines. The power take-off combine is eating into the market formerly held sacred to the big machine, indicating future sales of the 10-ft cut and larger of fewer than 6,000 per year. There are at least eight concerns, perhaps more, who make large combines. That doesn't provide much for any one of us, if we all stay in it.

Will the trend to the self-propelled type spread to the small power take-off combine field? I believe it will to some extent. In much of the West, 5 and 6-ft combines are very frequently equipped with auxiliary engines. The power take-off machine leaves much to be desired so far as steady, even operation of the combine itself is concerned. A self-propelled 7-ft machine running 5 mph will do just as much or more work than a 12-ft, tractor-drawn machine and cost no more. It will cost but little more than a 6-ft machine with an auxiliary engine. So I believe there is a ready market for a limited number of 7 or 8-ft cut self-propelled machines, particularly in the plains states. We have a few out this year, and they have been snapped up. Logically, however, the self-propelled principle can best be applied to any type of farm machine where at present a tractor is required for propulsion plus an engine and in most cases, though not always, an operator on the pulled machine.

Will the trend to self-propelled units spread to other farm machines? I believe it will.

In my opinion we are now at the beginning of a period when we will really equip farms with modern, labor-saving equipment. Certainly we have come a long way on that path but nowhere near far enough. The best equipped power farmer today is just about where the ordinary factory owner was 40 years ago. He had a power plant — a boiler room and a good steam engine. It had a high pressure and a low pressure cylinder, and a governor with a pair of big iron balls whirling around, a long drive rod hooked up to a crank which operated a big fly wheel and belt pulley on one shaft. The belt — most often double leather 24 in wide, but sometimes a flock of manila ropes — ran out through a small hole in the wall into the next room. In that room were the machine tools all hooked up by a maze of vertical belts running up to the lineshafting which occupied just about every foot of space under the ceiling. Each machine had a set of cone pulleys, top and bottom, and an idler pulley from which the belt was guided to the driven pulley by a long wooden arm reaching down to the operator. What a screech they made as the machines were thrown into motion, or when the planer was reversed! As we see it now, it was terribly crude and wasteful of power and labor, but it was a wonderful advance from what preceded it.

Now there is none of that, except in a few farm implement plants I know only too well! Each machine tool has its own motor, sometimes two,

The Massey-Harris 7-ft self-propelled "Clipper" combine

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three or four motors. They run and use up power only when machine is working. I expect the machines and motors cost more in total than the same room filled with belt-driven machines, line shafting, and belts hooked to one prime mover, but they do much more work with less power, fewer men, greater efficiency than ever before.

In my mind, even the best equipped farms in America are, from a labor-saving standpoint, just about where our factories were 40 years ago. Why should the mobile power on a farm be tied up in just one package — the tractor? The usefulness of that machine was far more than doubled when it became in fact a self-propelled farm machine, by mounting tools on it. Internal-combustion engines are cheap and good. Certain savings in design of a tool can be made by putting an engine on it rather than making the tool attachable to the tractor. We hear of quick-attachable and quick-detachable tools, but it still takes a full day to mount a corn picker on a tractor, and it is certainly impractical to remove the picker at any time during the picking season. Thus the tractor is useless for any other work during from 30 to 90 days in the fall when there is fall plowing, bean harvesting and other jobs to do. A lighter and cheaper engine to drive the implement can be used because it will work fewer hours per year and need only be large enough to furnish the power required by the machine of which it is a part.

I believe there is a great opportunity for labor-saving on farms through designing self-propelled corn pickers, balers, swathers, forage harvesters, certainly cotton pickers, sugar cane machinery, beet harvesting machinery, mobile pea viners, and a good many other machines of that general class.

Perhaps there is some merit in a design which would permit the power plant to be quickly taken off one of these machines and put on another. But combination machines of this kind have rarely proven practical. That is one of the serious objections to many machines now mounted on tractors — it takes too long to put them on and take them off — too much time that costs more money than ever before and which probably will continue to cost more money for years to come.

Should the self-propelled idea become fairly general, there may be a trend toward custom work. That supposed objection has already been made to self-propelled combines. I don't worry about that. The laws of economics will work there, and I presume in a system of free enterprise we who make farm machinery must be willing to recognize that what is economically best for our farmer customers is best for us in the long run.

It is true that at the present time the self-propelled combine seems to lend itself well to custom work. And it is also true that some farm machinery folks are worrying about it, expressing the fear that should this trend develop it might curtail the sale of combines. It is my opinion that this sort of thinking is just as fallacious as that indulged in by folks who feel they can plan production and sales in the future on the basis of conditions which exist now.

Self-propelled combines are being used largely in custom work this year because there is a terrific shortage of large combines and a tremendous acreage of small grains to be harvested. It is a war emergency situation, and it would be a crime this year to keep any combine from cutting every possible acre it can cut. But I believe in normal times, when a man can own a combine and cut his wheat for 75c to $1.50 per acre, including all expense and depreciation, he isn't going to pay a custom man from $2 to $5 to do the same job. Neither is he going to put himself in a spot where he will worry himself sick watching his grain get dead ripe while waiting for the custom machine. So I don't believe there is much to this fear of custom combining becoming very popular under normal economic conditions.

I would like to mention a rather unusual activity we are carrying on this year — the Massey-Harris Harvest Brigade. We sold 500 of our 14-ft self-propelled combines (for cash) to 500 operators, each of whom has pledged himself to cut a minimum of 2,000 acres this season. These machines were largely sold in the great plains states, from Texas to North Dakota, and in California and the Pacific Northwest. Approximately 400 were delivered to the owners in the plains states, at points in Texas, Oklahoma, and southern Kansas. Most of them are experienced operators, many having been local custom operators in the past. They are now all down there in Texas and Oklahoma, starting on the winter wheat crop. They will carry on up through Kansas, Nebraska, Colorado, the Dakotas, Minnesota, and Montana, each cutting a maximum number of acres during the next 90 days. Our aim is to cut a million acres. From reports already in, I believe we will greatly exceed that figure.

We expect to get this job done with about 300,000 man-hours less than it could be done with tractor-drawn combines, regardless of size—and that is a saving of over 60 per cent in labor alone. We expect to save ½ million gallons of fuel and, best of all, put ¾ million bushels of grain into elevators and ultimately into food-grain that would be left on the ground in opening the fields if harvested with tractor-drawn combines.

The money value of this grain we will save at prevailing prices will practically equal the whole purchase price of the entire five hundred machines. The value to people who will get this food to eat, that would be left wasted in the fields, is a different and a very much more important matter.

Referring again to the custom combining problem, in the territory in which our harvest brigade is operating — west of a line drawn from the Red River of the North down through the east border of Texas — there are just about 80 million acres of wheat, rye, oats, barley, rice, and grain sorghums to be harvested this year. Last year there were 76 million acres, and for the past 10 years an average of 64 millions. This means that the 1944 crop is 16 million acres, or 20 per cent larger than the 10-year average, and one of the largest small-grain harvests in America's history is now being harvested. And the crop in the area mentioned has to be harvested with 163,210 combines of all sizes, shapes, and ages, plus what binders are used. Let's say binders will take care of 20 per cent of the crop. That will leave 64 million acres to be combined, or just under 400 acres per machine. Based on the average harvested for the past 10 years, these machines would have 312 acres to cut, so in 1944 they each have a good deal more work to do, even though the 10-ft and larger machines average nine years of age. Obviously the job could hardly be done without additional equipment. Truly the harvest is plenteous but the laborers, men and machines, are few.

Now comes the 500 Harvest Brigade machines, each of which is pledged to cut 2,000 acres. Thus each is doing the work of five combines and using two-fifths the man power and about two-thirds of the fuel per acre cut. We expect these 500 machines to cut 2 per cent of this entire crop. At this time, when we are so woefully short of man power, fuel, and combines, surely this is a worth-while effort. It is a wartime emergency program and couldn't

The Massey - Harris 12-ft self-propelled combine

possibly be undertaken under normal conditions. The machines are owned by individual farmers who live all over the states covered by this campaign. Each should earn enough to pay for his machine and all of his operating expenses. Our part in it consists of furnishing the machines, organizing the campaign, keeping the records, and awarding four or five thousand dollars worth of war bonds to the twenty or so men who do the best jobs.

We confidentially expect these 500 men and 500 machines to harvest more grain in one season than ever has been harvested by 500 men in the world's history. Incidentally, the campaign offers a splendid opportunity to gather performance records—cost of fuel, repairs, wear and tear on machines in the field and in transport, cost of operation, etc.

Here is the record, just coming in, twelve machines located in Texas, Oklahoma, Arizona and California, that are working in barley, flax, oats and wheat: Acres cut, 4761; hours cutting, 1040.5, fuel used, 3755 gal. This gives the following averages: Acres per hr, 4.58; gallons of fuel per acre, 0.783; gallons of fuel per hr, 3.61; acres cut per machine (to date), 396.75.

Some of these machines were cutting in heavy, irrigated crops. Here is the exact record of one machine in wheat, the crop most of the machines will harvest:

Acres cut	380
Hours cutting	82.5
Fuel used, gal	260
Grease used, lb	25
Oil used, qt	8
Repairs	None
Cost of fuel and lubricants	$40.75
Acres per hour	4.47
Fuel per acre, gal	0.685
Cost per acre, fuel and lubricants	10.8c

These figures are as reported. Estimating labor at $1.00 per hour, 10 per cent depreciation in value for 380 acres (which might be considered an average year's cutting for one combine) and 2 per cent for repairs, we would get $310, which added to fuel and lubricant expense would make a total cost of $350.75, or 93c per acre as the cost of owning and operating a self-propelled combine which is used to harvest 380 acres of wheat per year. With a 17-bu yield per acre, this would give us a net cost per bu of 5½c, or just about one-fourth the cost of binding and threshing, or, in my opinion, less than two-thirds the cost of a tractor-drawn combine.

Discussion by S. D. Pool

THE trend toward self-propelled farm machines is apparent and an increase in their use is forecast when the advantages over conventional pull type equipment will be determined by individual farm requirements, the cost to the farmer, and, above all, the actual cash dividends which accrue by the use of this equipment. The ease and comfort afforded the operator can be attractive and decisive in many instances, but these features alone will be secondary to the majority of operators who must depend upon a minimum amount of labor in producing farm crops at the lowest cost.

The advantages and features of self-propelled farm machines were appreciated in the early development of the tractor and records of many attempts are available where inventors tried to integrate both tillage and harvesting equipment in early tractor designs. Records of our early research and development of the Farmall tractor disclose the adaptation of practically all types of harvesting and tillage tools to the general-purpose tractor we visualized at that time. All of these attempts, it is true, were crude from the standpoint of tractor and implement design of today. The tractors and equipment were heavy, the steel wheels packed the ground, the engines and transmissions were too wide, the wheels were non-adjustable with the consequence that serious limitations were set up with respect to latitude of row spacings, and there were but few places to mount equipment satisfactorily. The industry has made much progress in the last twenty years.

The progress in the mechanical design of tractors and farm machinery of today discloses opportunities for the future which could not have been visualized in the early conception of self-propelled implements. The widespread use of the general-purpose tractor and allied equipment has familiarized the trade with its ability and performance. Design engineers today have a clear cross section of crop requirements, and our present tractors will most certainly be outmoded by the sleek, slim-waisted lines of future designs. Product design and styling will be of little value if the functioning does not promote a greater versatility of the equipment in accommodating the wide variance in crop-row spacings and harvest requirements.

Hydraulic control or adjustment of farm implements can make possible the mounting on the tractor of many implements never previously tractor mounted. Tractor-mounted tools save the weight and cost of axles, wheels, and other essentials of implements previously designed to be pulled behind a tractor. Of even greater importance is the fact that, with hydraulic adjustment of these tools, physical effort is eliminated making it possible for any member of the family to do field work. This flexibility and convenience of operation will enable the farmer to till his soil at the precise depth which experience has shown is ideal for that particular crop and soil.

The tractor-mounted corn picker has appealed to many farmers regardless of the effort and time required for tractor mounting. These problems will unquestionably be solved. However, from an operational standpoint the mounted picker has been established on the merit or advantages of a self-propelled machine. General-purpose tractors are ideally suited to a corn picker. The operator's station and steering wheels are effectively located for visibility and accuracy in guiding the unit over the corn row. The location of the drivewheel is most important for propelling the unit and trailing the wagon over the wet fields and narrow headlands.

The principles governing the design of a self-propelled combine, however, are unlike those of the tractor-mounted picker. The cutter bar must be located completely in front of and extend over the full width of the machine. In turning corners, the grain side end of the cutter bar must recede so as not to leave any uncut grain. Consequently the location of the drive and steering wheels are definitely fixed by the cutter bar location, the distribution of machine weight, and grain accumulated in the tank. Self-propelled combines, because of the inherent design established, are able to back out of wet spots and travel over soft fields considered impassable with a tractor and pull type machine.

The advantages of a self-propelled combine may be compared with a tractor with its complement of mounted tools; each has great advantages with respect to maneuverability and economy of operation. The tractor, however, has a multiplicity of uses, and its initial cost can be defrayed against an entire farming operation, whereas the self-propelled combine is limited to the one job of harvesting. Regardless of this fact, a self-propelled combine will pay attractive dividends, where acreage, climatic conditions and crops justify this type of machine. The self-propelled combine releases the tractor on the farm for plowing and summer fallowing which may be done at the same time as harvesting, thus conserving the moisture which is available for subsequent crops.

S. D. POOL is assistant chief engineer, East Moline Works, International Harvester Co.

This picture shows the McCormick-Deering self-propelled harvester-thresher in action, at the left. At right is shown the International Harvester Company's automatic twine baler

The front-cut feature is decidedly advantageous in that the usual back swaths are eliminated. Even in the smallest fields, a 12-ft machine can be operated almost as efficiently as in large fields. There is no time lost in preparation for transporting, going through narrow lanes, and traversing the highways since the width of cutter bar represents the total width of the machine. The operator's station is an ideal location for efficient cutter bar control and driving safely on the highway. These features and advantages over conventional pull machines could well make this type of machine predominantly the choice of custom operators.

It might well be stated that a self-propelled combine is the combination of a tractor, combine and motor truck, in that basic elements of each have been incorporated in this machine. Obviously, if this complex machine is to be reliable and safe, and can traverse the extremes in harvest fields as well as on the highway, the engine, transmission, clutches, wheels, brakes, etc., must be equal in automotive design to that of a tractor or truck. The combine mechanism, likewise, must be designed in keeping with these standards, in order that the entire unit may continue to operate with a minimum of service. These various mechanical elements or units are all necessary in a self-propelled combine, whether it be a comparatively narrow cut machine or a wide machine. We can expect, therefore, that the weight and cost of a self-propelled machine will be greater, per foot of cut, than a pull *(Continued on page 348)*

Temporary-Portable Silos

By Hugh C. Smith
ASSOCIATE A.S.A.E.

THERE are two good reasons for knowing more about temporary and/or portable silos. First, these available and quickly set up silage containers may be a lifesaver for farmers, unless feed, labor, and material shortages ease off this year. Second, knowledge of temporary silos before use not only increases the satisfaction obtained but also increases the scope of their usefulness.

Through continued use the term "temporary silo" has been applied to the paper-lined, fence-ring type of emergency silo. (Also known as the "snow-fence", "portable", "paper bag", and "sisalkraft" silo.) Successive rings or sections are set up as the lower one is firmly packed with silage. The height of the finished silo must not exceed its diameter by more than four feet. Experiments have shown that preservation of the silage in this type of silo depends largely upon uniform distribution of the fine and coarse particles in the silo, a definitely damp moisture content, and reasonably uniform packing of the finely chopped feed. A paper lining is used to exclude air and to bridge the openings in the supporting fence for tighter packing. Paper can perform these functions if designed for the purpose and installed with sufficient slack to throw the full weight of the silage onto the supporting fence.

Temporary silos are unloaded (fed out) by shoveling the silage over the side rather than through side doors. As each ring or section is unloaded, it is removed, thus facilitating further unloading. The fence may then be stored for use in future silos, or used immediately for other fencing needs around the farm. The paper lining must be renewed for every filling of the silo.

More detailed, illustrated instructions for the construction and use of temporary silos are available without charge through retail lumber yards or county agents, farm advisors or agricultural college offices.

As to its drawbacks, the first cost of a temporary silo is too low. It neither properly reflects the real over-all cost nor the real over-all values and conveniences that are purchased. Many buyers are careless with them because they seem "cheap".

Actually the continuing costs of annual relining and re-erecting and the constant costs of finer chopping and uniform packing of the silage for a "temporary" silo can accumulate eventually into the cost of a "permanent" silo. These added costs are more than offset for the careful user, in that uniformly packed silage is almost always better than silage packed by gravity alone; also on construction costs, because temporary silos give value received (plus values) each year they are filled or the materials are put to other uses. Following are some of the "plus values":

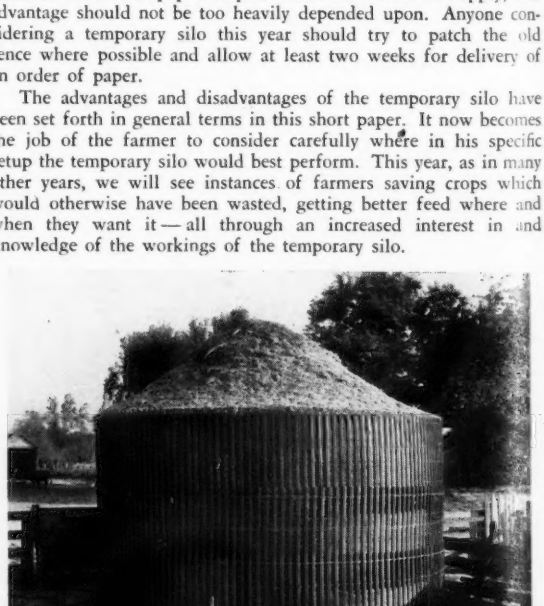
1 The *low first cost* of a temporary silo enables more farmers to try out silage in the first place than would otherwise be possible. A beginner with silage (or with a new grass or other silage) tries it in a temporary silo with an investment of less than $50. It is also true that the silo may be increased or decreased in size the following years, or may be completely abandoned after the first trial without loss of capital investment, because the fence may be used for many other purposes. The trial does not obligate one in scope or continuation of his program beyond the current year.

2 The value next most welcomed by users of the temporary silo is its *flexibility* or *adaptability* to current crop, herd, market, or weather factors. Whether the temporary silo is used to supplement a larger permanent silo, or is the only silo a man has, he need buy and erect no more nor less silage capacity than his best judgment dictates. This year's temporary silo has little if any effect on the height, diameter, or location of the same silo used in succeeding years.

3 *Portability* in silos has economic significance as well as novelty. Beginners with silage pick up valuable work simplification lessons by trying temporary silos in a variety of locations during the first few years before a permanent silo is "set" in the ground. Tenant farmers transport their temporary silos from farm to farm, in one trip of a pickup truck, between fillings. Orchardists, ranchers, etc., change the temporary silo location each year, building up the fertility of the filling and feeding locations and saving the costs of a two-way haul by merely walking their cattle to the field where the crop was grown.

4 *Availability* is a mixed "plus value". In normal years, this advantage of being ready at the nearest lumber yard or in the farmer's own barn, to be picked up, built and filled in one day, is an invaluable asset to farmers caught with weather-damaged crops or more crop than the regular silo will hold. Nowadays when demand for fence and paper keeps almost on the heels of supply, this advantage should not be too heavily depended upon. Anyone considering a temporary silo this year should try to patch the old fence where possible and allow at least two weeks for delivery of an order of paper.

The advantages and disadvantages of the temporary silo have been set forth in general terms in this short paper. It now becomes the job of the farmer to consider carefully where in his specific setup the temporary silo would best perform. This year, as in many other years, we will see instances of farmers saving crops which would otherwise have been wasted, getting better feed where and when they want it — all through an increased interest in and knowledge of the workings of the temporary silo.



A temporary-portable silo lined with "Sisalkraft"

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Nutritional Values of Hay and Silage as Affected by Harvesting, Processing, and Storage

By G. Bohstedt

CERTAIN losses in nutritive value inevitably take place during harvesting, processing, and storage of hay and silage. Far greater losses take place during the harvesting and storage of roughages than of grains. These losses vary from about 10 per cent under near-ideal conditions to more than 40 per cent under only too common unfavorable conditions of weather, or inadequate machinery, labor, and storage.

While such is the situation in roughage conservation, animal husbandmen are in position to appreciate that in regions of relatively long winters perhaps no greater boon could be conferred upon the livestock industry than changing the quality of roughages from what they customarily are to the high quality they might be.

Hay of high quality is indispensable for maintaining health and thrift in young animals between pasture seasons and for satisfactory breeding performance of mature animals in so far as nutrition can make sure of satisfactory reproduction. A host of spring ailments in livestock is met on farms, ailments which are traceable to poor hay fed during the winter.

PART I. HARVESTING, PROCESSING, AND STORING HAY

The original feed value of a hay crop can most effectively be conserved by the retention of all leaves and by a rate of drying that quickly stops respiration, enzyme action, and fermentation. It has been said that an ideal way of curing hay would be an immediate transfer of the freshly cut forage to a vacuum oven and rapid drying at a low temperature. Artificial drying approximates this ideal. This temperature control, especially control of the outlet temperature in reference to dryness of hay, is highly important. But up to now this process has not been widely adopted for practical farm use. More economical means for making high-quality hay need to be found.

The three major criteria for quality in hay are leafiness, color, and freedom from foreign material. The latter requirement has greatest force in the case of unpalatable or harmful weeds, less so when the extraneous material is merely hay of another species, perhaps equal or nearly equal in feeding value.

The importance of leafiness is readily appreciated from the fact that leaves contain most of the feed value of a hay crop. In alfalfa, leaves make up about 50 per cent by weight but contain 70 per cent of the protein and 90 per cent of the carotene, or provitamin A, of the entire plant. Considering that the leaves are about 40 per cent more digestible than the stems, the difference in protein, carotene, and other nutrient content in leaves as compared with stems is still further increased.

Green color in hay is highly appreciated, for the reason that the presence of visible green chlorophyll and the invisible or occluded yellow carotene are fairly closely correlated. Only the carotene or provitamin A has any important biological significance. While in a general way we can depend on leafy green hay to be correspondingly rich in carotene, there have been cases where hay after a period of storage, in spite of having retained its green color, had nevertheless lost a large part of its carotene.

Carotene Best Index of Quality. The carotene content is probably the best single criterion of quality in hay. A high carotene content usually means that the hay is leafy legume hay, that whether grass or legume it has been cut at an early stage of growth, has been cured with a minimum loss of leaves, and has been cured to a dryness that has effectively stopped or greatly reduced respiration, enzyme action, and fermentation. As a result, not merely the carotene but also the other vitamins and the protein, carbohydrates, fat, and ash are well preserved.

Carotene is the precursor of vitamin A, also referred to as provitamin A, in which form only is vitamin A present in plants or forage crops. If vitamin A were present as such in plants, it would be fortunate in that vitamin A is more stable than is carotene, which is easily affected by plant enzymes, specifically carotenase, which under conditions of sufficient moisture and temperature destroy carotene during storage. Thus alfalfa hay artificially dried and therefore with enzymes largely destroyed or inactivated has been shown to lose only about one-fourth of the carotene during a six months' storage, whereas ordinary sun-cured alfalfa hay frequently loses about half of its carotene during the first six months' storage[2]*.

Maturity of Hay Crop; When to Cut. The younger or the less mature a hay crop, the richer it is in protein, minerals, and vitamins. At the Michigan Agricultural Experiment Station[13] it was found that alfalfa on April 25 had 432, on May 16, 278, and on June 13, 150 micrograms of carotene per gram of dry matter.

Wheat at various stages of growth in a test by Virtanen and coworkers[16] had the following milligrams of carotene in every 100 g, and a titration value of vitamin C for every 1 g, of dry matter:

			In head	Bloom		Milk		Ripe
Days of age	7	24	40	46	58	64	74	93
Carotene	.22	.22	.22	.19	.11	.07	.05	.02
Vitamin C	33	20	10	8	5	5	4	4

Alfalfa before bloom contains 19 per cent protein, at one-third bloom 15 per cent, at three-fourths bloom 14 per cent, and past bloom 13 per cent protein. Meanwhile the fiber has increased, making what protein and other nutrients are less digestible.

At the Huntley, Mont., field station of the USDA Bureau of Dairy Industry[5], fields of alfalfa grown under irrigation were cut in early bloom, half bloom, and full bloom, and each kind of hay fed as the only ration of Holstein cows. Apparently no survival problem with the crop was involved in this case. The protein contents of the three cuttings were 18.2, 18.2, and 15.7 per cent. In pounds of field-cured hay per acre, the early-bloom stage yielded 8,938, the half-bloom 8,888, and the full bloom 6,940 lb, thus yielding 1,427, 1,381, and 997 lb protein per acre. The cows fed the three different kinds of hay yielded during the lactation 404, 345, and 331 lb butterfat from the early to late cuttings, respec-

A J. I. Case tractor operating a sweep hay rake and stacker

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*Superscript numbers denote the references appended to this paper.

tively. So if there is no danger from leaf hopper injury to the aftermath, a reasonably early cutting is desirable in alfalfa and is definitely desirable in other hay crops. It is frequently recommended that alfalfa be cut when one-tenth to one-fourth in bloom, clover when one-half to three-fourths in bloom, grasses when only fully headed and in partial bloom.

Hay made from early growth of grasses and legumes needs to be fully as dry as that made from more mature growth in order to keep from overheating in the barn mow. This is because young plants respire more vigorously after being cut and therefore produce more metabolic water, both factors during storage favoring increase in temperature and consequent destructive oxidation. Heat that is self-generated in this manner always occurs at the expense of nutrient material, especially the easily digested nutrients like sugar. This is to be remembered in the case of after-drying wilted hay by forced ventilation, and where after intermittent ventilation there is a rise in the temperature of the hay.

Respiration with its inevitable end products of heat, carbon dioxide, and metabolic water, incidentally explains the frequently observed slight increase in moisture content of freshly harvested and stored grain and silage, as well as hay.

What Time of Day to Cut; Diurnal Fluctuation. Growing plants undergo a daily cycle during which metabolism and storage is increased during the time of day when sunlight and temperature are at their maximum. It has been found by Greenhill[6] that the dry matter content of forage was greatest between noon and 3:00 p.m. The increase in midday cuts was usually about 3 per cent, rising in one test to 7 per cent. Greater increases than this have been reported in other work but have been drawn into question on account of the small samples used.

Mechanical Losses. The shattering of leaves is one of the most serious losses in hay making for the reason that leaves approximate concentrates in digestibility and feed value. That high-quality leafy hay largely takes the place of grain is attested by the results of a feeding experiment at the Wyoming Agricultural Experiment Station[23]. When cows on roughage alone were changed from poor quality stemmy to good quality leafy roughage, they increased in milk yield as much as when 8 to 12 lb grain were added to the ration.

Due largely to differences in the shattering of leaves Watson[16] reports the following losses of dry matter in the several conservation processes used: Ordinary hay making, 22.1 per cent; hay making with special appliances, 17.4 per cent; artificial drying, 7.5 per cent.

Weather Conditions. Leaching and bleaching as well as shattering of leaves, are some of the worst weather hazards affecting hay. It has been demonstrated that from 20 to 40 per cent[24] of the nutrients of hay can be extracted by soaking in cold water, these nutrients being the soluble and therefore the most easily digestible, also biologically some of the most important nutrients of hay. Damage from rain is less severe soon after mowing of the hay crop when the cells are still alive and metabolizing but increases in severity as the plant cells die. Also repeated showers are more damaging in this respect than one heavy rain. Rain prolongs the life of plant cells and therefore prolongs respiration. After the cells die, they lose their selective permeability and yield up their nutrients to the leaching action of rainfall.

The vitamin B complex is affected in that it is water soluble, therefore easily leached out. This action also affects vitamin C although little of this vitamin is found in hay of any kind.

The following factual observations on losses of feed value in terms of starch equivalent were made in a Swiss experiment:

GOOD VERSUS BAD WEATHER[21]

Percentage loss in haymaking based on nutrients in fresh grass

Details of treatment and weather	Loss of starch equivalent, per cent
(No mechanical loss) No rain	23
(Mechanical loss) No rain	39
Rain	50
1 to 2 showers (1-20 mm)	44
5 to 6 showers (12-63 mm)	54
Average of all trials	45

Weather conditions involve bleaching as well as leaching, and the destruction of the green color also destroys the pigment vitamin carotene as well as some other vitamins. Smith and Briggs[12] found that, when alfalfa leaves were removed and stored in a cupboard as compared with leaves exposed to sunshine for varying lengths of time, there was a greater loss of 20 to 33 per cent of vitamin A activity in 2¾ to 6¾ hr in the leaves kept in the sunlight. There was, however, no appreciable loss of green color. In leaves kept overnight in a field there was, however, a 75 per cent loss of vitamin A activity, and one week's exposure to the sun resulted in severe bleaching with 96 per cent loss of vitamin A potency.

Molded hay is unpalatable, is lower in its vitamin and over-all nutritive value. While molds of different species or colors seldom are harmful, nevertheless the conditions that bring on mold growth may make hay dangerous especially for horses. Also the conditions favorable for molds are in some cases, as for instance second-year sweet clover, conducive to the formation of dicoumarin. This is responsible for the so-called sweet-clover disease that causes cattle and at times other livestock to bleed to death.

Swath vs. Windrow Curing. Hay which is cured entirely in the swath during sunny weather is bound to incur severe losses from shattering of leaves due to the fact that leaves and stems differ greatly in their rate of drying. Zink[27] showed that where the drying of hay in the swath approached a moisture content of 30 per cent, the leaves had a moisture content of only 9.3 to 11.8 per cent and were crisp enough to crumble or shatter through very little agitation.

Approved methods of hay making, therefore, require windrowing the hay after only a few hours' exposure in the swath. Cox[4] found that in the windrow leaves and stems lost moisture at approximately the same rate.

Rather satisfactory hay, always considering the vagaries of the weather, can be made by the partial swath and windrow-curing method. Kiesselbach and Anderson[9] curing hay by different methods to a moisture content of 30 per cent state that hay cured in the swath throughout reached this condition of dryness in 27 hr but lost 18.5 per cent of the dry matter. When cured in the swath for 2 hr and then cocked, it took 32 hr, incurring a loss of only 2 per cent of its dry matter. It was concluded that the most practical method was to cure for 3 hr in the swath and then put it in a windrow, thus reaching the 30 per cent moisture content in 27 hr with a loss of only 1.7 per cent of the dry matter.

The sizes of windrow naturally affected the time necessary for curing. Partially swath-cured hay graded higher than the hay that was entirely swath-cured or that was windrowed immediately after mowing.

Whatever practical method of hay harvesting and storing promises to reduce the moisture content rather quickly to 24 to 20 per cent or less, and with leaves still attached to stems, warrants thorough investigation and encouragement.

The time element here is important, for the reason that respiration still goes on at moisture contents below 38 per cent[22]. Destructive enzymatic action continues at very much lower moisture contents, although practically stops at 10 per cent moisture.

That the carotene content of alfalfa hay during the curing process may best be preserved in cocks, second best in windrows, and poorest in the swath, was found by Wallis[18a], and is shown in the following table:

LOSSES IN THE CAROTENE CONTENT OF ALFALFA HAY CURED BY DIFFERENT METHODS

Curing period, days	Carotene per pound in dry matter when hay was cured		
	Swath, mg	Windrow, mg	Cock, mg
0*	145	145	145
1	108	91	107
2	40	72	111
3	15	43	109
4	7	41	92
6	1	21	†

*Fresh material taken when cut.
†Hay spoiled. No sample taken.

It was stated that the hay in the swath and windrow was ready to haul by the end of the second day, when the former had 40 and the latter 72 milligrams carotene per pound of dry matter.

The same investigator in two years' work found that the vitamin D content of alfalfa hay was in an inverse relationship to that of the carotene content with the three methods of curing, and therefore varied in direct relationship to exposure of hay to the sun. It was concluded that the most practical method of making hay was curing it in small to medium-sized windrows after a few hours' drying in the swath. This made for favorable amounts of both carotene and vitamin D.

The rate of drying the stems may be greatly increased by crushing brought about by a mower crusher reported on by Zink[26]. Such a device, if at all practical on farms, would commend itself no matter how the hay subsequently was to be processed.

Baling in the Field. Harvesting by means of the field baler, especially the one-man operated type of field baler, has considerable popular appeal. In the humid sections of the country obviously the greatest handicap to successful field baling is moisture and the rate of moisture reduction. From the following table, presenting data on hay baled at different moisture contents, it is seen that a moisture content of around 20 per cent made for highest digestibility and brightest green color.

BALING IN FIELD[20]

	Baled at moisture contents (per cent) of:						
	16	20	24	28	32	36	40
Digestibility of organic matter	55	60	59	52	56	55	53
Remarks	Some green	Fresh green	Some green	Some green; brown patches	Very little green; patches of dark brown	Dusty and presence of mold; brown	Very dusty; brown

It seems that at 16 per cent moisture content some bleaching had occurred, and at 24 per cent moisture content at least some discoloration through heating had begun to take place, this discoloration being aggravated at still higher moisture contents.

In a preliminary test at Purdue University it has recently been demonstrated that wilted alfalfa hay containing from 30 to 35 per cent moisture could successfully be field-baled and then dried to a low moisture content (12 per cent) by forced ventilation in the barn. This initial test involved 7 tons of hay, stacked 7 ft high, within tight sidewalls. The bales were stacked crosswise to the bales in the tier immediately underneath, with no attempt at spacing. The support underneath the hay was a simple wooden lattice work on top of 2x6's put on edge on the mow floor. The spaces between the 2x6's served as laterals for the ventilation tunnel. Air currents from the floor were kept passing upwards continuously among the bales during the course of 14 days. The ventilation was powered by an electric motor equipped with an airplane type fan. The hay in this test turned out very good in color and aroma.

The question has been raised whether there might not be a place for smaller bales, or therefore smaller cross sections of bales than have been standard all along. Such smaller bales might be entirely feasible with automatic field balers, and might assure the practicability of baling merely wilted hay and afterdrying such baled hay in the barn.

Chopping in the Field. While most farmers thus far are more interested in field baling than in field chopping, the latter mechanized procedure of haymaking has increased in use, no doubt for the reason that the same machine can be used for making grass silage and even corn silage. Where the hayfield is reasonably close to the barn, a two-man crew has managed to keep a field chopper going fairly steady where the chopped hay is blown rearward into a trailer, and periodically distributed if necessary by the single operator with this outfit. The second man would haul the trailer loads to the barn and there blow the chopped hay into the barn mow or other storage.

One of the worst aspects of such field chopping is that when hay is sufficiently dry for storing as chopped hay, the leaves are so powdered by the repeated blower action as to cause a dust nuisance in the barn.

In case the hay is not sufficiently dry for this process, the stored hay is more likely to heat and discolor than is long hay, unless special structural or mechanical arrangements are made. Woodward and Shepherd[28] found that alfalfa hay stored at 25 to 27 per cent moisture content when chopped lost all traces of green color during storage whereas considerable of the green color was retained in the long hay. The long hay in this case was more efficient than the chopped hay in tests with milking cows.

Afterdrying by Forced Ventilation. To prevent as much as possible the separation of leaf and stem through field chopping, even more to avoid rainfall on hay in the open, considerable hope is attached to field chopping of wilted hay having from 40 to 50 per cent moisture, to which moisture content the hay may frequently be reduced after only 3 or 4 hr curing in the sun. Such partly dried chopped hay then is put into a barn mow equipped with a forced flue ventilation system. While in repeated tests at experiment stations and on a great many farms *long* wilted hay has been successfully afterdried in a barn mow, there are few experimental results so far in the aftercuring of *chopped* wilted hay. To be sure, there are skeptics as to the practicability of the latter system, and while unquestionably it has its problems, it is entirely possible that they can be overcome. If so, we shall have advanced far in this difficult task of making high-quality hay by mechanization. Preliminary work at Wisconsin under the leadership of F. W. Duffee has been successful in this respect.

We shall look for chopped hay which is green, with most leaves attached to stems, and with a minimum amount of dust present. Such hay then would be rich in carotene and in all of the other nutrients originally present in the fresh green crop.

Those farmers who normally sell a certain amount of their hay could readily bale the chopped hay in twine-wrapped cylindrical bales, as was done in the Wisconsin work referred to. If the chopper is set for the longest possible cut, such hay may possibly even be satisfactorily baled in the plunger type of baler.

Mention was made under the subheading "Baling in the Field" that some initial work has demonstrated the apparent feasibility of field-baling wilted hay and, by forced ventilation, afterdrying this baled hay when stacked in a suitably constructed barn mow or other place of storage.

Where the curing of hay after only a few hours' exposure to the sun is completed in the barn, a question may be raised here the same as it is raised with artificially cured hay. Might there, because of lack of vitamin D as ordinarily imparted by the sun, be trouble in feeding, even though such hay might be several times as rich in carotene as ordinary hay. In answer it may be stated that of the two vitamins carotene is the far more critical one, practically speaking. Carotene cannot be purchased at low cost as can vitamin D which in the form of irradiated yeast, or by way of the irradiated principle of ergosterol in other carriers, is the cheapest of all vitamins. One-half pound of irradiated yeast, costing at present about 30c, when added to a ton of calf meal, pig meal, or other grain mixtures of four-footed farm animals, will effectively protect them against rickets.

Chaffing of Mow-Cured Hay. In some short-time Wisconsin tests of palatability of mow-stored dry hay, thereafter differently processed, cattle preferred to eat the loose hay, or the longest chopped hay (1.8-in cut of a hay chopper), to the shorter cuts of hay, these being 1-in, ½-in, and ¼-in cuts. In most experiments reported, cattle have preferred long hay to chaffed hay, although in a few tests cows have eaten more pounds of chaffed than of long hay. In the main, it has not paid to chaff or grind mow-cured hay, and the Wisconsin experimenters conclude that only when hay is scarce and high priced and is rather coarse will it pay to chaff it and in that way get cattle to consume it with the least refuse. It has not paid to chaff or grind leafy, fine-stemmed hay except, when in the form of a hay meal such as alfalfa meal, it is to be used in feed mixtures for pigs, poultry, sometimes dairy calves, infrequently other livestock.

Storage. A tight roof, or an effective cover, and a dry base are essentials for the storage of hay. Concrete floors have at times caused loss especially in baled hay, hence the frequent provision for straw or wooden overlays to separate the hay from the damp concrete. As has been mentioned, the presence of the oxygen of the air, moisture, and temperature determine loss in hay, no matter in what condition it is stored.

With reference merely to air or oxygen, it was found at Jealott's Hill[19] that with artificially dried grass which was ground and then stored for 130 days there was, with no application of pressure, a loss of 27.4 per cent carotene, with 2-lb pressure per square inch a 10.3 per cent loss, with 12-lb pressure per square inch a 7.1 per cent loss, and with 48-lb pressure per square inch a 6.6 per cent loss of carotene. This suggests that the deeper the hay is stored in a bent of the mow, provided the hay is sufficiently dry at the start, the smaller the loss in storage. Honcamp and associates[7] showed that the composition and digestibility of properly stored meadow and clover hay has remained constant over 3 and 2 years' storage periods, respectively. There was less loss of color and vitamins the greater the compaction.

Bethke and Kick[3] found little difference in loss of carotene between hay stored ground and unground, where the hay in either case was sufficiently dry for storage at the start.

Salting Hay. Salting hay has been a traditional practice on many farms in various countries of the world. This practice has carried down to date, in spite of the fact that carefully controlled experiments have pointed to the failure of salt to inhibit bacterial fermentation and molds unless applied in excessive and physiologically harmful quantities. Salt has not prevented spontaneous combustion. At the same time certain advantages from the addition of salt have been observed. Thus Shutt[11] reports on four stacks of clover-timothy hay in each treatment, one set of stacks receiving no salt, the next 10 lb of salt per ton, the third 20 lb of salt per ton, and the last 30 lb of salt per ton. Examinations of the different hays gave the salted hay a better color. It was more leafy, less dusty, and of better aroma. He further reports that 30 lb of salt seemed too much to feed, that the cattle were somewhat loose, but the other two salted hays were relished somewhat better than the unsalted hays.

While the addition of limited amounts of salt may have such minor advantages, salt should not be depended upon to make improperly cured hay safe for storage.

Brown Hay. As inadequately cured hay is put into storage, its biological activities are continuing, resulting in a considerable destruction of the best, most easily digested nutrients. As the temperature rises and the moisture is driven outward from the center of the mass, a good bit of the sugar and other carbohydrates in the hay are caramelized, resulting in a sweet taste which is liked by cattle. However, much of the nutritive value, especially of its vitamin content, is destroyed. The protein is greatly reduced in digestibility, as shown by Kellner[8] who found that in meadowgrass hay of light brown color the protein was 86.5 per cent digestible, in dark brown hay 75.1 per cent digestible, and in black hay only 2.6 per cent digestible. Albert[1] found these percentages of digestible protein in the dry matter of hay varying in intensity of brown color: In (normal) hay 10.8, light brown hay 10.0, medium brown hay 9.1, dark brown hay 0.4, very dark hay 0.0 per cent digestible protein. The total protein had not gone down to any great extent, but the digestibility, as seen from the above figures, had been severely reduced. Swanson et al[14] stacked alfalfa with 40 per cent moisture, resulting in the following losses: Protein 32.7 per cent, fiber, 46.5 per cent, nitrogen-free extract 45.4 per cent, and fat 63.6 per cent.

"BROWN HAY" IS A COMPROMISE BETWEEN HAY AND SILAGE

In parts of Europe where hay-curing weather is unfavorable, "brown hay" is made purposely. Thus partly cured hay with about a 50 per cent moisture content is built into large heaps or cocks, preferably on straw laid over planks, with the hay thoroughly tramped, and put under pressure. The temperature may go to 175 to 200 F and maintain for several weeks. Meanwhile the moisture may go down to about 15 per cent, resulting in the brown caramelized hay which is sweet to the taste but which has had most of the feed value and vitality cooked out of it. Such "brown hay" in a way is a compromise between hay and silage, but except for mere palatability, answers the purpose of neither.

Spontaneous Combustion of Hay. There is no clear unanimity of agreement on the exact causes, or sequence of developments, in stored moist hay that lead to spontaneous combustion. Watson[17] indicates three successive stages, the first one being a temperature increase to about 120 F, brought on by respiration and bacterial activity. This temperature involves no great nutritive loss. The plant cells are dead at the end of this stage.

The second stage is from 120 to 158 F, which latter temperature is the warning point. Thermophilic bacteria are able to raise the temperature to this stage, but all bacterial action is stopped at about 176 F.

In the third stage, which lies above 158 F, there is a further increase in temperature, with a formation of certain organic acids, up to a critical point of 195 F, after which by dry distillation volatile compounds are formed which are easily oxidized under suitable conditions and where the material may burst into flame, often with explosive violence, on access to air. According to Miehe's theory[15] the carbon left after the distillation process is pyrophoric, being capable of extremely energetic oxidation. Pyrophoric iron appears to act as a catalyst. According to Roethe[10] losses from spontaneous ignition of hay can be reduced if it is stacked or put into a barn mow with a moisture content not higher than 30 per cent.

SUMMARY

Quality in hay is more important than quality in any other feed in the prevention of deficiency diseases in livestock during northern winters.

The younger the growth for harvesting, the higher the nutritive value of the hay crop.

The carotene content is the best single criterion of quality in hay.

Carotene preservation in hay largely depends on a quick reduction of the moisture content to from 24 to 20 per cent without undue exposure to the bleaching action of the sun.

The drier the hay, the less the enzyme action which is destructive of carotene. Hence dehydrated hay having only about 10 per cent moisture best preserves its carotene.

About half of the carotene in ordinary hay is lost during the first 6 months of storage.

A deficiency of vitamin D in hay made with little or no exposure to sunshine need not cause serious concern, because vitamin D may cheaply be supplied by other means.

Curing hay partly in swath, partly in windrow, is recommended as practical means for avoiding shattering and bleaching of leaves.

Respiration with its self-generated heat takes place at the expense of nutrients, primarily the sugars.

Chopping or baling in the field, unless special means for ventilation are provided during storage, requires fully as dry a condition as where the hay is to be stored as long hay.

Forced ventilation for wilted hay, especially where this can be harvested by a pickup chopper or field baler, holds promise for producing high-quality hay by mechanization.

Pressure or compaction during storage, once the hay is sufficiently dry, is a factor in preserving carotene.

Salting of hay cannot be depended upon to compensate for improper curing, but may impart a degree of palatability.

"Brown hay", as produced by storing merely wilted hay in relatively small batches, under pressure, is quite palatable but has had much of its nutritive value, practically all of its carotene, destroyed.

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(Concluded in October issue)

Baffle Type Energy Dissipator for Pipe Outlets

By Vito A. Vanoni and James T. Rostron

(Concluded from the August issue)

ALL OF the information needed to design a pipe outlet structure is summarized in Figs. 7 and 8 by means of graphs, sketches, and formulas. In arranging this information it has been assumed that the design discharge is determined by field conditions only and that the width of the structure is fixed within limits by conditions at the site. The main points in the design are discussed below with a view to clarifying them and facilitating their application.

DESIGN FORMULAS

Fundamental Hydraulic Formulas. The design formulas are expressed in terms of the two fundamental hydraulic variables, F_0, the velocity head factor, for the pipe flow, and d_c, the critical depth for the width, W. The first of these is expressed by

$$F_0 = \frac{V_0^2}{gD_0} = \frac{16Q_0^2}{\pi^2 g D_0^5} \qquad [1]$$

where the expression on the right is obtained by introducing the equation,

$$V_0 = \frac{Q_0}{A_0} = \frac{Q_0}{\frac{\pi D_0^2}{4}}$$

d_c[1] is given by the familiar expression

$$d_c = \sqrt[3]{\frac{Q_0^2}{W^2 g}} \qquad [2a]$$

Substituting Q_0 from equation [1] into equation [2a] gives

$$d_c = D_0 \left(\frac{\pi}{4} \times \frac{D_0}{W} \right)^{2/3} F_0^{1/3} \qquad [2b]$$

The energy equation for the system may be written in the form

$$E = (K_e + K_f + K_m + 1) \frac{V_0^2}{2g} + h_0 \qquad [3a]$$

where E is the total available head, and K_e, K_f, and K_m are respectively, the loss coefficients for entrance, friction in the pipe, and miscellaneous causes. By substituting h_v for $V_0^2/2g$ and by estimating average values of the loss coefficients and the back pressure, h_0, equation [3a] becomes

$$h_v = 0.3E \qquad [3b]$$

Lacking better information, this is a good value of h_v to use in making the first trial calculation to determine D_0. The method of calculation is shown in detail under "Design Example."

Formulas for Baffle-Box Dimensions. All of the dimensions of the baffle box are defined by Figs. 1 and 7 and their values are given as formulas in Fig. 7. These dimensions have been assigned lower limits that are determined by practical, hydraulic, and structural considerations. For instance, the minimum value of the baffle height, h_3, is such that sufficient room is allowed to turn the jet issuing from the pipe. It is easy to see that this value must be more than the pipe diameter, and the minimum value of $1.5D_0$, determined by experiment, therefore appears reasonable.

Formula for Back Pressure on the Pipe. The formula for back pressure is based on the equation

$$h_0 = h_2 + \frac{V_2^2}{2g} \qquad [8]$$

where V_2 is the velocity through the gap between the cap and the headwall. V_2 may be taken as

$$V_2 = \frac{Q_0}{WKd_c} \qquad [8a]$$

where K is a numerical factor which varies with the velocity head factor and the width ratio of the structure. Introducing [8a] into [8] gives

$$h_0 = h_2 + \frac{1}{K^2} \times \frac{Q_0^2}{2W^2 d_c^2 g} \qquad [8b]$$

Analysis of the data on back pressure showed that the coefficient, $1/K^2$, could be expressed as

$$1/K^2 = 4.0 \times (W/D_0)^{.41} F_0^{-.05} \qquad [8c]$$

Introducing this equation into equation [8b] and dividing through by D_0 gives

$$\frac{h_0}{D_0} = \frac{h_2}{D_0} + 4.0\,(W/D_0)^{.41} F_0^{-.05} \times \frac{Q_0^2}{2W^2 d_c^2 g D_0} \qquad [8d]$$

Introducing equations [1] and [2a] gives

$$h_0/D_0 = 2(W/D_0)^{-1/3} + [1.5 + 2.0\,(W/D_0)^{.41} F_0^{-.05}] \times [\pi/4 \times D_0/W]^{2/3} F_0^{1/3} \qquad [8e]$$

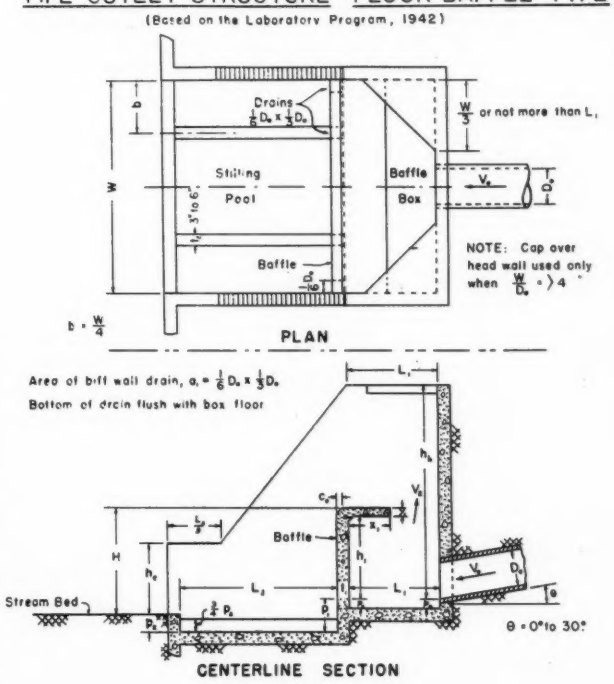

PIPE OUTLET STRUCTURE - FLOOR BAFFLE TYPE
(Based on the Laboratory Program, 1942)
Drains
Stilling Pool
Baffle Box
Baffle
W/3 or not more than L1
NOTE: Cap over head wall used only when W/D0 > 4
b = W/4
PLAN
Area of biff wall drain, a = 1/6 D0 x 1/3 D0
Bottom of drain flush with box floor
Stream Bed
θ = 0° to 30°
CENTERLINE SECTION
DESIGN DATA
Q0, E, and W determined by field conditions. For first trial design calculate hv from equation (3b) to obtain V0, D0, F0 and W/D0, and then get h2/D0 from chart (b).
Q0 = Design Discharge in c.f.s.
Q1 = Discharge thru drains = 0.2 Q0 approx
L1 = 3.0dc ; L1(min) = 2 OD0 (5)
h1 = 2D0(h2/D0)^1/3 + 1.5dc ; h1(min) = 1.5D0 (6)
x1 = 0.5h1 (L1 - x1)(min) = 18" (7)
hv = h0 + dc (9); h3 = 3.0dc (10)
L2 = C√Hdc (Standard Drop Design) (15)
cc(max) = 0.5t1 ; c(max) = 0.3x1 (amount of fillet under cap)
y, and t1 to be determined by structural requirements

Fig. 7.

[1] R. L. Daugherty, "Hydraulics," pp. 285-7, McGraw-Hill, New York, 1937.

The curves of Fig. 8(b) were calculated from this equation.

Formulas for Sidewall Dimensions. The height, h_h, of the headwall given by equation [9] in Fig. 7 is sufficient to give adequate freeboard. Since the height of the water surface above the floor of the box is very nearly equal to h_0, the freeboard provided is equal to d_c. The depth of water over the end sill was found to be about $2d_c$. Therefore, by making the height of the wall at this point equal to $3.0d_c$, a freeboard of d_c is provided at this point also. The other sidewall dimensions shown in Fig. 7 were determined by experiment.

Splash caps over the corners formed by the headwall and sidewalls are to keep water which rises in the corners from overtopping the walls. They are found necessary only in wider structures since in narrow structures there is no tendency for the water to rise higher near the sides than at the center of the headwall. Splash caps are used on structures with width ratios of 4 or greater. Their effectiveness in increasing the safe overload capacity may be seen in Fig. 9 which shows a structure operating at an overload of about 40 per cent.

Formulas for Stilling Pool Dimensions. The formulas for the stilling pool dimensions follow those developed by Morris and Johnson‡ for the gully control drop. The length, L_2, of the pool which is given by equation [15] is taken directly from the gully drop. The value of the length coefficient, C_L, is given by curve (c) of Fig. 8. The depth of the pool, P_2, is made $0.6d_c$ (equation [13]) since according to experiments this value gave the best performance. This depth is 20 per cent greater than in the gully drop and is required to handle the more severe conditions resulting mainly from flow through the drains in the baffle. Two longitudinal sills of height $\frac{3}{4}P_2$ are placed at the quarter points as shown in Fig. 7.

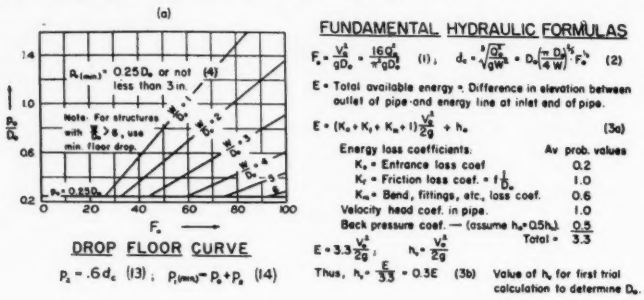
In order to prevent silting of the baffle box, the top of the end sill of the stilling pool should not be higher than the floor of the box. However, the pool can be lowered as much as desired as long as its length is made according to equation [15].

Drains through Baffle. On the basis of experiments and practical considerations, the four drains through the baffle were made $1/6D_0$ wide by $\frac{1}{3}D_0$ high. As shown in Fig. 7, two of the drains are placed flush with the side walls and two are at the quarter points. The bottom of all the drains is placed flush with the baffle box floor.

Structural Dimensions. In the laboratory study, no attempt was made to determine structural dimensions of any of the walls. However, pressures which must be resisted by the structure were measured in the baffle box. For design purposes it will be satisfactory to assume a uniform pressure over the entire baffle equal to $0.25(h_0 + h_v)$ and a pressure head acting over an area of D_0, opposite the pipe outlet equal to $0.75(h_0 + h_v)$. The pressure head on the headwall and sidewalls may be assumed to vary linearly from h_0 at the base to zero at a distance of h_0 feet above the base. The resultant unit pressure on the cap may be assumed as $0.2(h_0 + h_v)$ acting over the entire underside of the cap in the upward direction. It is probable that most of the structural dimensions will be fixed by earth-pressure loads and by considerations other than water pressure.

To prevent chipping and cracking of the exterior corner at the intersection of the baffle and cap, it is desirable to chamfer the corner. The effect of the chamfer on flow conditions is merely to increase effectively the length of the stilling pool by the amount of the chamfer because the crest of the fall is moved upstream by that amount. Hence, the maximum value of the chamfer, $c_c = 0.5t_1$, specified in Fig. 7, is based entirely on practical and structural reasons, and therefore this value may be varied. It was shown by experiment that the fillet, c_1, at the intersection of the wall and the cap can be made as much as $0.3x_1$ without appreciably affecting the performance of the structure.

‡Hydraulic Design of Drop Structures for Gully Control, B. T. Morris and D. C. Johnson. Trans. Am. Soc. C. E., v. 69, 1943, pp. 887.


(a)
FUNDAMENTAL HYDRAULIC FORMULAS
DROP FLOOR CURVE
(b)
BACK PRESSURE CURVE – $\frac{h_2}{D_0}$ Contours vs F_0 vs. $\frac{W}{D_0}$
(c)
$C_L = 2.5 + 1.1\left(\frac{d_c}{H}\right) + 0.7\left(\frac{d_c}{H}\right)^2$
$L_2 = C_L\sqrt{Hd_c}$ (15)
APRON LENGTH COEFFICIENT vs RELATIVE HEIGHT OF FALL

NOTE: * Contours of chart (b) obtained from the solution of eq. (8a).

DESIGN CHARTS for PIPE OUTLET STRUCTURE FLOOR BAFFLE TYPE

Fig. 8

DISCUSSION OF RESULTS

Effect of W/D_0 on Baffle Box Dimensions. The width ratio determines the proportion of the flow which is deflected upward or toward the sidewalls by the baffle and consequently plays an important part in fixing the dimensions of the baffle box. Formulas [4], [5], [6] and [7] show that as the width is increased and more of the flow is turned sideways the baffle can be lowered and placed nearer to the outlet. It also may be seen that the structure size increases slowly with an increase in flow capacity. Since the flow pattern is not affected by the velocity head factor until the water has reached the free surface above the baffle cap, the baffle-box dimensions are not strongly influenced by the discharge rate. When the discharge is increased considerably, only a small increase is required in the size of the baffle box to provide satisfactory performance. Consequently a particular structure will operate successfully over a considerable range of discharges, up to the design flow of the structure. Thus in the design equations the baffle-box dimensions are a function of W and D_0 primarily and of F_0 to a lesser degree. The effect of the width ratio on the flow pattern and design dimensions is illustrated in Fig. 10. Both structures are designed for the same discharge.

In contrast it may be stated that other types of energy dissipation structures, such as those employing the hydraulic jump, require a considerable increase in size when the discharge *(Continued on page344)*

Back to Elm Street, U. S. A.

Back from the business of killing—to the business of living!

Back from scenes of hatred, despair and destruction to a homeland of peace, hope and opportunity!

Millions of young Americans are coming back to thousands of farms—to thousands of peaceful Elm Streets in every city, town and village of America!

They've made up their minds to a lot of things while they've been away.

They've seen the suffering of homeless terrorized families—people who have lost their self-respect, their hope, their health — *everything.*

They've seen a large part of the world in ruins, because a few fanatical men sold "gold bricks" to millions of people who traded in their freedom for promises of security—for brightly painted pictures of a "planned economy" under an all-wise, all-powerful government.

And they want no part of that sort of thing here in America.

They want jobs. They want to plan their own lives. Make their own futures. Go places under their own power.

And we must give them that opportunity.

But to do it, wartime restrictions and controls must be removed from agriculture, business—*and the individual citizen*—as quickly as possible.

Farmers must be free to plant what they want, and as much as they want—without needless bureaucratic supervision.

Taxes must be adjusted so that money will be available to finance the change-over to peacetime production.

Greater incentives must be provided, so that workers can make *more* money, by making *more* goods for *more* people.

Mr. Private Citizen must be allowed to make money—and be free to invest it in business ventures of his own—or of others.

Prosperity has always come to America through the *growth* of production—not its restriction—on farms and in factories.

Profitable production *will make jobs* for the boys who are coming back. But business, labor, agriculture and an *understanding* government must *work together* to create it—hold it—and increase it.

BUY WAR BONDS AND STAMPS —AND KEEP THEM!

The Army-Navy E flag waves over 7 Republic plants and the MaritimeM floats over the Cleveland District plant.

REPUBLIC STEEL

GENERAL OFFICES: REPUBLIC BUILDING, CLEVELAND 1, OHIO

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WOVEN WIRE FENCING • BARBED WIRE • STEEL FENCE POSTS • BALE TIES
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CARBON, ALLOY and STAINLESS STEELS for FARM and DAIRY EQUIPMENT

(Continued from page 342)

GLOSSARY OF TERMS

b = distance from sidewalls to centerline of longitudinal sills in stilling pool, ft
b_1 = width of drain opening, ft
$C = \left(\frac{\pi}{4} \times \frac{D_0}{W}\right)^{2/3}$ = a critical depth coefficient
c_e = exterior chamfer of baffle, ft
c_i = fillet at corner formed by cap and baffle, ft
C_L = stilling pool apron length coefficient
C_f = Coefficient of energy loss
D_0 = Diameter of pipe outlet, ft
$d_c = \sqrt[3]{Q_0^2/W^2g}$ = critical depth, ft
E = a specific energy, ft-lb per lb
ΔE = loss of energy, ft-lb per lb
f = friction factor for pipes
$F_0 = V_0^2/gD_0$ = velocity head factor
g = gravitational acceleration, ft/sec^2
H = net drop from baffle crest to stream bed, ft
h_E = entrance head loss, ft
h_f = friction head loss, ft
h_L = total losses in pipe leading to structure, ft
h_e = height of end wall, ft
h_h = height of head wall, ft
h_0 = back pressure head on pipe outlet, ft
$h_v = V_0^2/2g$ = velocity head of flow in pipe, ft
h_1 = net height of baffle, ft
K = coefficient in back pressure equation
K_e = loss coefficient for entrance
K_f = loss coefficient for pipe friction
K_m = loss coefficient for miscellaneous causes
L_1 = length of baffle box, ft
L'_1 = top length of side wall, ft
L_2 = length of stilling pool, ft
L'_2 = horizontal sidewall dimension for stilling pool, ft
L_s = overall length of structure, ft
l = length of pipe carrying discharge to structure, ft
p_0 = drop in floor of baffle box below pipe invert, ft
p_1 = drop of stilling pool floor below pipe invert, ft
p_2 = depth of stilling pool (height of transverse or end sill)
Q_0 = design discharge, cfs
Q_1 = discharge through baffle drains, cfs
t_1 = thickness of baffle, in
$V_c = \sqrt{g_c y}$ = critical velocity, ft/sec
V_0 = velocity of flow at pipe outlet, ft/sec
V_2 = velocity of flow discharging from baffle box, ft/sec
V_3 = velocity in downstream channel, ft/sec
W = width of structure, ft
x_1 = overhang of baffle cap, ft
y_1 = thickness of cap, ft
θ = slope of inlet pipe, deg

becomes materially greater, and also require greater structure lengths with increasing values of W/D_0 because of the distance required for the spreading of the high velocity jets issuing from the pipe outlets before the formation of a jump is possible.

Fitting Structure to Field Conditions. From a study of the design data and charts of Figs. 7 and 8, it becomes clear that this structure is designed to operate under conditions of relatively high velocity discharge. As an example, assume that a structure with a 1-ft pipe is designed for a factor, F_0, of 16. Then from equation [1] the velocity head is 8 ft and the velocity and flow in the pipe are 22.7 fps and 17.8 cfs, respectively. Even with this relatively small velocity head factor and small pipe, the velocity and discharge are high.

On the back-pressure chart, Fig. 8 (b), the solid lines indicate the range of conditions under which the structure is most efficient and economical. The dashed lines give the back pressure for narrow structures with low velocity head factors. These structures generally are less economical than those in the range covered by the solid lines. For instance, if field conditions indicate that an extremely narrow structure is desirable, it may be possible to effect a saving in total cost by using a wider structure even though the excavation costs may be increased. The main factors in this saving are reductions in wall height and structure length. Structures with width ratios of approximately 6 appear to be the most economical. However, the optimum width depends largely upon field conditions, and therefore must be determined by the designer. Although structures designed according to the charts will operate satisfactorily, it is probable that simpler and cheaper structures can be devised when velocity head factors are below 8.

The pipe size for a system including a baffle-energy dissipator is calculated as it would be for any pipe line which has a submerged outlet. The amount of the submergence is equal to the back pressure created by the installation of the structure, and its value is given by curve (b) in Fig. 8. However, before the back pressure can be determined, F_0, and therefore the diameter of the pipe, must also be known. In designing a structure, several trial calculations are usually required before the correct size of pipe is determined. To reduce to a minimum the number of trials required, average probable values of the losses have been assumed and an equation [3b] obtained which gives a value of h_v for the first trial calculation to determine D_0. It should be noted that once the pipe diameter is determined, the discharge can be increased on a given installation only by increasing the total head. This can be done only by raising the water level over the inlet to the pipe. Since the inlet is usually a box forebay or small reservoir with limited freeboard, the water surface, and therefore the total head, cannot be raised to any great extent. Practically, this means that it is not possible appreciably to overload a pipe outlet structure and in designing this feature must be kept in mind.

Construction and Maintenance Considerations. In fixing the dimensions of the baffle box, it was necesary not only to give consideration to the hydraulic performance of the structure, but also to keep in mind other practical requirements. For instance, the gap between the baffle and the headwall was made sufficiently large so that the flow was not throttled. In the smaller structures this gap may become quite small, making it difficult to build the box and to clean it out if that becomes necessary. Therefore, in order to provide room for construction and cleaning of the box the gap was made 18 in minimum.

(Continued on page 346)

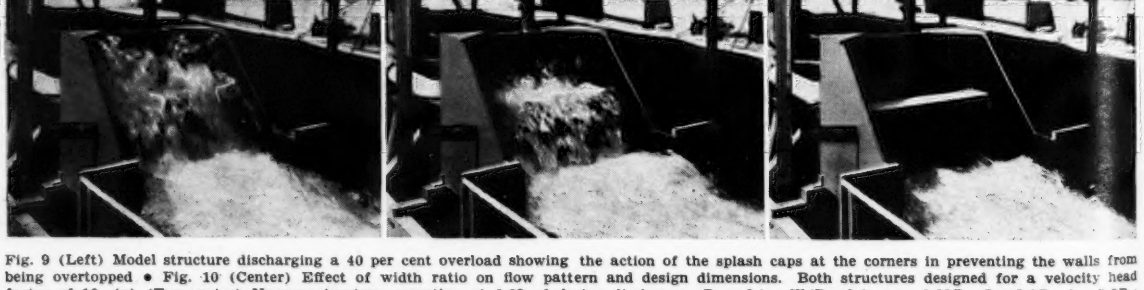
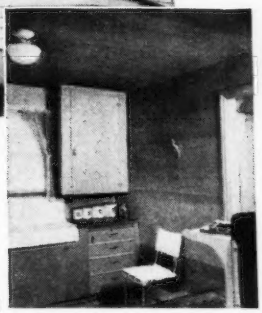


Fig. 9 (Left) Model structure discharging a 40 per cent overload showing the action of the splash caps at the corners in preventing the walls from being overtopped • Fig. 10 (Center) Effect of width ratio on flow pattern and design dimensions. Both structures designed for a velocity head factor of 16. (a) (Top center) Narrow structure operating at 0.83 of design discharge. $D_0 = 3$ in; $W/D_0 = 3.0$; $p_0 = 0.33D_0$; $L_1 = 3.2D_0$; $h_1 = 3.0D_0$; $x_1 = 1.5D_0$; $h_0 = 5.2D_0$; $h_h = 6.7D_0$; $L_2 = 5.2D_0$; $p_2 = 0.66D_0$;. (b) (Bottom center) Normal width structure operating at design discharge. $D_0 = 3$ in; $W/D_0 = 6.0$; $p_0 = 0.3D_0$; $L_1 = 2.0D_0$; $h_1 = 2.1D_0$; $x_1 = 1.0D_0$; $h_0 = 3.8D_0$; $h_h = 4.7D_0$; $L_2 = 3.4D_0$; $p_2 = 0.41D_0$ • Fig. 11 (Right) Low flow in model showing all of discharge passing through drains in baffle. This prevents clogging of the pipe by debris-laden flow

East elevation of Roy Spar farm tenant house, Ada, Ohio.

Farm Tenant House of the Present and the Future

George R. Shier
Consulting Agricultural Engineer



View of north end of kitchen showing home-made cabinet work. Penetrating floor seal used for natural wood finish.

Opposite end of kitchen showing electric range and modern dining set. Plywall panels placed horizontally and nailed to native rough lumber framing by unskilled labor.

Rear downstairs bed room with plywood panels placed vertically on walls. Framing headers cut between studs behind all horizontal panel joints.

George R. Shier
Consulting Agricultural Engineer
Howard S. Sterner Company
Columbus, Ohio

"Mr. and Mrs. Roy Spar have lived on their farm near Ada, Ohio many years. When Mr. Spar's growing seed corn business and other farm activities required full-time help they decided to construct an attractive tenant house that would help to secure an intelligent tenant family.

"The present farm labor shortage has helped justify their foresight. When help is difficult to obtain they are able to offer living quarters better than those occupied by the majority of farm owners. Yet the house is simple in construction, as evidenced by the fact Mr. Spar did the carpenter work himself with the aid of farm labor. The plans were prepared by the Department of Agricultural Engineering, Ohio State University.

"Interior type plywood finished with a clear "Floor seal" has provided attractive wall and ceiling surfaces in kitchen, hall, bath and three bedrooms. Two rooms were plastered at Mrs. Spar's request to avoid monotony, but she now feels that all plywood walls would have been preferable. The house is now three years old and the plywood still presents an attractive finish, while the other walls are beginning to show the need for redecoration. When the natural wood walls do need refinishing this can be accomplished with stain, paint, or wallpaper without initial preparatory treatment."

Post-war farm tenants will desire better living conditions. The new farm houses to be built then will not be "miracle houses" but comfortable, durable houses in the traditional manner using the best of the new materials proved by the war emergency.

Douglas fir plywood's ease of handling and fabrication are especially appreciated by the rural builder. The wide range of decorative possibilities with commonly available materials is a boon to the amateur painter. The "shock-resistance" and the ease of refinishing are especially important in the tenant house.

War labor housing in all sections of the United States, and Army and Navy hutments both here and abroad have proved the dependability of plywood housing. Speed of erection, adaptability to simple design and weather resistance under all climatic extremes are features which mean improved housing for the farm tenant family of the future.

Brief Specifications:

Size—1½ story, 6 room

Erected—Winter 1941-42

Builder—Owner and farm labor. Skilled labor required for plastering.

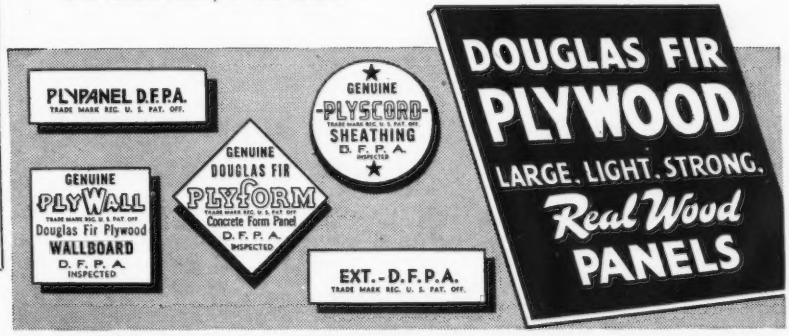
Framing—Conventional, with framing members placed behind all plywood joints.

Interior walls and ceilings—¼" Plywall grade. Douglas fir plywood placed vertically or horizontally directly on studding and nailed with 4d nails 6" on center. Panels butted and glued under the joints with urea resin adhesive.

Kitchen cabinet—¾" Plypanel grade Douglas fir plywood built in place by owner.

Finish on plywood—One coat of clear penetrating floor sealer.

DOUGLAS FIR PLYWOOD ASSOCIATION
Tacoma 2, Washington



SPECIFY DOUGLAS FIR PLYWOOD BY THESE "GRADE TRADE-MARKS"

Farm Buildings are War Equipment —Keep them Fit and Fighting!

(Continued from page 344)

The four drains through the baffle are designed to prevent the box from filling up with sediment. Danger of clogging is greatest during the lower discharges when quiet flow in the box permits sediment to deposit. By making the drains as shown in Fig. 7, they will discharge approximately 20 per cent of the flow when the structure is operating at design discharge. Laboratory experiments showed that with drains of this size the box was self-cleaning and could handle heavily laden flows without undue hazard from clogging. Fig. 11 shows the same model structure as in Figs. 9 and 10b operating at a discharge low enough to permit all of the flow to pass through the drains. It is seen that the stilling pool spreads the flow from the jets so that it discharges rather uniformly ove. he end sill.

Experiments showed that the performance of the baffle box was improved by dropping the floor slightly below the invert of the pipe. The dimension, p_0, in Fig. 7, is given by the curves of Fig. 8(a). It will be noted that the minimum value of p_0, is $0.25D_0$. For practical reasons it is recommended that this dimension be made not less than 3 in. This will facilitate the construction and also improve drainage of the pipe and baffle box during low flows.

TABLE 1. DESIGN CALCULATIONS

Quantity		Design Data Equation	Trial 1	Trial 2 (Hydraulic	Trial 3 Design)	Trial 4
Q_0	cfs	Field	40.0	40.0	40.0	40.0
E	ft	Field	26.0	26.0	26.0	26.0
W	"	Field	9.0	9.0	6.0	15.0
h_v	"	[3b] or $V_0^2/2g$	7.80	7.95	7.95	9.95
V_0	ft/sec	$\sqrt{2gh_v}$	22.4	22.6	22.6	25.3
A_0	ft²	Q_0/V_0	1.78	1.77	1.77	1.58
D_0	ft	Pipe diameter	1.51	1.50	1.50	1.42 (or 17 in)
F_0		[1]	10.2	10.6	10.6	14.0
W/D_0		Width ratio	5.96	6.0	4.0	10.6
h_0	ft	chart (b)	5.90	5.85	6.9	4.25
h_f	"	$f\times 1/D_0\times h_v$	9.30	9.55	9.55	12.6
h_e	"	$0.2h_v$	1.55	1.6	1.6	2.0
E'	"	$h_v+h_0+h_f+h_e$	24.6	25.0	26.0	28.8
		[3a]		(Baffle Box	Design)	
W	ft	str. width	Estimated	9.00	6.00	15.0
p_0	"	chart (a)	value of	0.375	0.375	0.355
C	"	$(\pi/4\times D_0/W)^{2/3}$	h_v slight-	0.257	0.339	0.176
d_c	"	[2]	ly low.	0.85	1.11	0.605
L_1	"	[5]	Choose	3.00	3.33	2.84
$2D_0(W/D_0)^{-1/5}$	"		nearest	1.65	1.88	1.29
$1.5d_c$	"		standard	1.28	1.67	0.91
h_1	"	[6]	size pipe	2.93	3.55	2.20
x_1	"	[7a]	and recal-	1.46	1.78	1.10
L_1-x_1	"	[7b]	culate all	1.54	1.60	1.74
L_1		[5] vs. [7b]	quantities			
			(Sidewalls and	Stilling	Pool	Design)
h_0	ft	Chart (b)		5.85	6.9	4.25
h_h	"	[9]		6.70	8.01	4.86
h_e	"	[10]		2.55	3.33	1.82
p_2	"	[13]		0.51	0.67	0.36
p_1	"	[14]		1.00	1.25	0.75
y_1	"			0.40	0.40	0.40
H	"	[16]		3.82	4.53	2.99
d_c/H				0.222	0.246	0.202
C_L		Curve (c)		2.75	2.80	2.70
L_2	ft	[15]		4.95	6.28	3.64
$W/4$	"	sills		2.25	1.50	3.75
$\frac{3}{4}p_2$	"	"		0.38	0.50	0.27
L'_1	"	[11]		3.00	3.33	2.84
L'_2	"	$L_{2/3}$		1.65	2.09	1.21
$W/3$	"	Splash cap		3.00	2.00	2.84
Drains	in	[18]		$3\times 6\times t_1$	$3\times 6\times t_1$	$2\frac{7}{8}\times 5\frac{3}{4}\times t_1$
				1.0 draw-down permitted in reservoir	Exact check of hydraulic gradient obtained	2.8 ft rise in w.s. elev. required to obtain Q_0
				26.0—25.0=1.0 ft		

DESIGN EXAMPLE

In order to clarify further the actual use of the design charts and equations, an example is presented. Assume that the following are established by field conditions:

1 Structure to be constructed at pipe outlet of an earth dam.
2 Design discharge, $Q_0 = 40$ cfs
3 Total available head, E = height of reservoir water surface above center of pipe outlet = 26 ft
4 Field conditions permit structure width from 6 to 15 ft
5 Length of pipe connecting reservoir and structure, 90 ft.

Following the procedure normally used for computing the size of a pipe line, the total available energy is equated to all of the losses in the system. Assumptions for values of the loss coefficients usually have to be made in the first trial calculation. In computing the pipe size when a baffle-outlet structure is included, the back pressure or static head loss must also be considered. The energy equation [3a] for the system is given in Fig. 8 of the design charts, and a value of h_v for the first trial calculation of D_0 is given by equation [3b].

A structure width of 9.0 ft, well within the limits stated in the assumption of field conditions, is chosen for the first trial design and a friction factor, f, of 0.02 is assumed for the pipe. The entrance loss is considered to be $0.2h_v$. To simplify the example, all other pipe line losses, such as those due to valves, elbows, etc., are neglected.

In Table 1 are listed some of the possible designs for a structure which will meet the above specified field conditions and in Table 2 complete computations are shown for the design listed as Trial 2. Photographs of models similar in appearance to the structures obtained in Trial Designs 2 and 3 are shown in Fig. 10.

TABLE 2. TRIAL DESIGN NO. 2

$Q = 40$ cfs; $W/D_0=6.0$; $E=26.0$; $D_0=18$ in; $W=9$ ft 0 in; $l=90$ ft

General data	Design formulas
$E=(K_e+K_f+1)V_0^2/2g+h_0$	Baffle box dimensions
$V_0=Q_0/A_0$; $A_0=\pi D_0^2/4$ =1.77 ft	$p_0=0.25D_0=0.25\times 1.5=0.375$ ft
	$L_1=3d_c$ or $2d_0$; $L_1=3\times 0.85=2.55$ ft
$V_0 = 40/1.77 = 22.6$ fps	$\therefore L_1=2\times 1.5=3.00$ ft
$h_v = V_0^2/2g = 7.95$ ft	$h_1=2D_0(W/D_0)^{-1/5}+1.5d_c$
$F_0= V_0^2/gD_0=2\times 7.95/1.5$ =10.6	$h_1=2\times 1.5/(6)^{1/5}+1.5\times .85=2.93$ ft
	$x_1=0.5h_1=1.46$ ft
$W/D_0 = 6.0$	$L_1-x_1=3.00'-1.46'=1.54$ ft, o.k.
	Sidewall dimensions
From chart (b) Fig. 9	$h_h=h_0+d_c=5.85+.85=6.70$ ft
$h_0/D_0 = 3.9$	$h_e=3d_c=3.0\times .85=2.55$ ft
$h_0 = 5.85$ ft	$L'_1=L_1=3.00$ ft
	L'_2, $L_{2/3}=4.95/3=1.65$ ft
$K_e =$ 0.2	*(For L_2, see stilling pool dimensions)*
$K_f = f(l/D)$ 1.2	Stilling pool dimensions
Vel. head = 1.0	$p_2=0.6d_c=.6\times .85=0.51$ ft
Loss Coeff. = 2.4	p_1 (min)$=p_0+p_2=0.51+.38=.89$ ft
	Make $P_1=1.00$ ft
$E'=2.4\times 7.95+5.85=25.0$ ft	Assume $t_1=0.5$ ft, $y_1=0.40$ ft
$E-E'=26.0-25.0=1.0$ ft	$H=h_1+y_1+p_1-p_2=2.93+0.40+1.00-0.51$
=reservoir drawdown permitted	$H=3.82$ ft; $d_c/H=.85/3.82=0.222$
Critical depth, $d_c=\sqrt[3]{Q_0^2/W^2g}$	From curve (C) Fig. 9, $C_L=2.75$
	$L_2=C_L\sqrt{Hd_c}=2.75\sqrt{3.82\times .85}=4.95$ ft
$d_c=\sqrt[3]{40.0^2/81.0\times 1/32.2}$ $=\sqrt[3]{0.615}$	Longitudinal sills, $b=W/4=2.25$ ft from sidewalls
	Height of sills, $\frac{3}{4}p_2=0.38$ ft
$d_c = 0.85$ ft	4 drains: $1/6D_0\times\frac{1}{3}D_0=3''\times 6''\times t_1$
	Length of legs of splash caps, $W/3$ or L_1 =9.0/3.0=3.00 ft

In reference to these designs (Table 1), several points may be mentioned. In Trial 1 the assumed velocity head was slightly low, and consequently a larger pipe was obtained than was necessary to discharge the flow. However, its value was nearly correct so that the nearest smaller standard pipe size was used for Trial 2 and the hydraulic gradient was recalculated. This gave a satisfactory solution for the hydraulic design which utilized all but 1.00 ft of the total available head, E. Therefore, the design of the structure was completed by following the equations and charts of Figs. 7 and 8. Experiment showed that 87 per cent of the energy existing at the pipe outlet is dissipated in passing the flow through this structure.

Since the total available head was not entirely utilized, it is possible to make an alternate solution using a narrower structure, which will have a higher back pressure. *(Continued on page 348)*

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SERVICE WILL PULL YOU THROUGH!

(Continued from page 346)

The design listed as Trial 3 is one based on a structure width of 6.0 ft and a pipe diameter of 1.5 ft which gives a width ratio of 4.0 for the structure. In this design, the hydraulic gradient was checked exactly, i.e., the sum of the losses of the system was equal to the total available energy.

Trial 4 design was made assuming that a 17-in diameter pipe was available. Hence, to design a structure which will best fit the existing field conditions, it will be necessary to reduce the back pressure to a minimum since all other losses will be increased by using the smaller pipe. Therefore, 15 ft, the maximum possible structure width, is chosen for calculating the design. In this solution it was found that for design discharge the losses exceeded the total available head by 2.8 ft so that the dam height must be raised by that amount unless the freeboard is to be reduced. It is possible that the design discharge could be carried by a 17-in pipe if one having lower friction losses and an improved entrance could be used. The system as originally assumed will discharge 37.6 cfs, or $0.94Q_0$ under a head of 26 ft.

From the number of designs given to fit the assumed field conditions, it is evident at once that there is more than one satisfactory solution to the problem. Therefore, the design which must ultimately be chosen will be determined by an economic comparison, or by other considerations that are affected by the local conditions.

SUMMARY AND CONCLUSIONS

The pipe outlet structure described in this paper and developed through laboratory experiment is designed to dissipate high velocity flow from a pipe outlet so that it can be discharged safely into an erodible channel. A general design has been developed that will cover all combinations of rate of discharge, pipe diameter, and width of structure likely to be encountered in practice. Performance of the structure is such that flow discharging from the stilling pool is uniformly distributed across the width, thus presenting a favorable condition for erosion control at this critical point.

The dimensions of the baffle box in particular and the structure as a whole were worked out very carefully to determine the smallest possible structure that would give satisfactory performance. Changing any one or several of the dimensions results either in poorer performance or in increased cost. All the information necessary to design a structure is given by the drawing, formulas, and charts of Figs. 7 and 8.

AUTHORS' ACKNOWLEDGMENTS: The authors wish to acknowledge the friendly participation of Mr. J. G. Bamesberger, who visualized the field problem and was largely responsible for initiating the investigations, and of Mr. Karl O. Kohler, Jr., who kindly reviewed and criticised the results. Appreciation is also expressed for the friendly assistance and advice of Professor Robert T. Knapp and for the cooperation of the members of the staff of the Cooperative Laboratory. The laboratory investiagtion was started under the guidance of Mr. Brooks T. Morris, who was also responsible for designing the apparatus for the small scale tests.

The Self Propelled Combine

(Continued from page 336)

type machine of the same size; and logically the narrower the cut, the greater the differential between each type of machine.

Our field experience and the information compiled from our tests indicate the importance of proper combine selection by a farmer in keeping with his requirements. A combine which has too narrow a cut for a given acreage will increase the cost per bushel of harvesting, as well as labor for handling. On the other hand, these costs must be balanced against the initial investment necessary for various types of machines available and the possible loss of grain, if he is dependent upon his neighbor or custom operators for his threshing job.

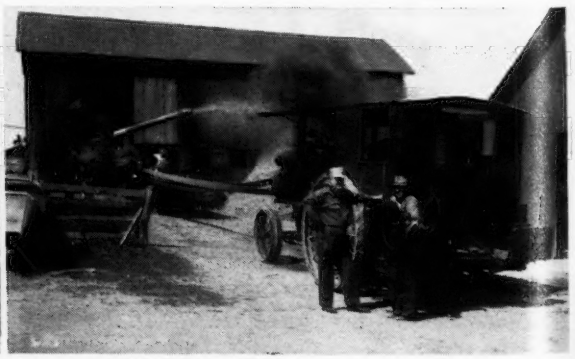
With opportunities now open to farm labor in urban industrial areas, at higher wages and shorter hours, the farmer has become more and more dependent upon his immediate family and modern equipment to produce his crops. If this situation continues, and indications are that it will, farmers will be faced more than ever before with the necessity of one-man operating equipment, and the larger operator may find it desirable and more economical to procure large single-purpose machines. The small farmer, if he is to compete with his produce, is similarly faced with an equipment problem, and since diversification is the basis for a successful operation we must have a complete line of tools expressly suited to his needs and his pocketbook. The small tractor with mounted equipment would seem to offer this small operator the most efficient equipment at the lowest initial investment.

Our country's success will continue to be dependent upon its ability to produce food economically, and our postwar period will place on our farmers greater demands for increased production. Future farm equipment must continue its advance in taking the hard work out of farming and thus make this occupation both profitable and pleasant.

Emphasize Education

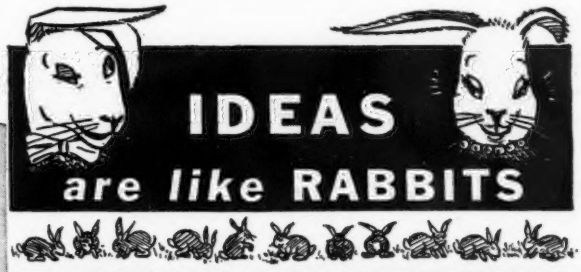
(Continued from page 327)

As a profession and as a Society we are well fitted to foster education. Something like half of our membership is or has been connected with the colleges. Our immediate A.S.A.E. past-president, in both talent and experience, is qualified to give well-balanced guidance to educational extension, and our current president is a man of notable energy and vision both in education and in engineering. Both the needs of the times and the leadership available suggest this as the moment to emphasize education.



1944 REMINDER OF WHEN STEAM POWER WAS IN FLOWER

"Where there's smoke, there's always fire," so instinctively argues W. H. Mitchell, chief of the St. Joseph, Michigan, fire department. The smoke in this instance, however, was harmless, but it led him on one of his rural jaunts last month to what is probably the last surviving steam threshing rig in southwestern Michigan, shown in these pictures — a Port Huron tandem compound steam engine and Goodison thresher owned by Arthur Brownell who has been threshing with steam power since 1910. "Mitch" — in the cab at the left, and who himself was a first-rate engine and "separator" man a quarter century ago — happened along just at the right time to take over temporary operation of the rig for Mr. Brownell who was suffering from an injury. What memories this scene calls up for those who were boys on the farm before steam power made way for the more efficient, if less picturesque "gas" tractor! What a thrill used to come — and still does — from that odoriferous blend of steam, soft coal smoke, and threshing dust! And how some of us youngsters of yesteryear envy Mitch his opportunity again to "pull the throttle" on a steamer! — EDITOR



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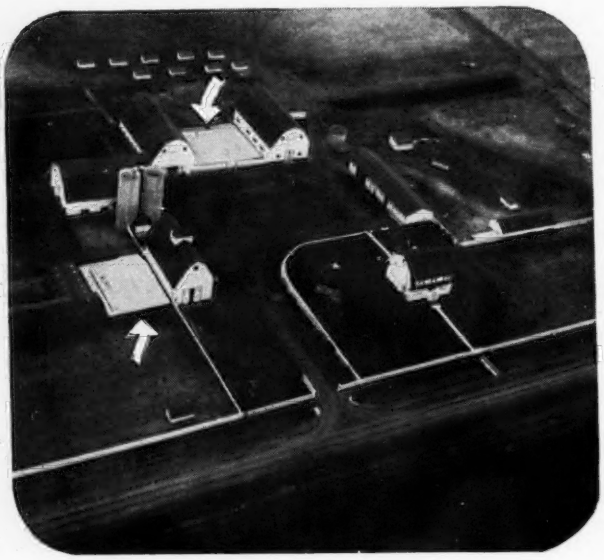

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BUY MORE WAR BONDS

Tests of Plywood Panels

By M. A. Sharp
MEMBER A.S.A.E.

IN connection with the construction of plywood silos reported in AGRICULTURAL ENGINEERING for February, 1944, H. A. Arnold, associate in agricultural engineering research at the Tennessee Agricultural Experiment Station, made some tests to determine the amount of pressure plywood panels might be expected to sustain. Panels 4x4 ft and 2x2 ft were used for this construction. Results indicate that a 4x4-ft panel could be used at the bottom of a 24-ft silo but would not allow very much of a safety factor. The test was made by glueing the panels to 2x4 frames, the lap around the edges being 1¾ in. Shingle nails spaced 2 in apart were used to hold the plywood in place until the glue cured. One panel was made with the knotty side in and the opposite panel with the knotty side out.

It was assumed that the side having the most imperfections would fail first due to the greater stress in the outside fibers. This proved to be the case, and although pressures sustained are not as high as they would have been otherwise, it seemed best to test the plywood under the most adverse conditions. The panels were bolted together with a gasket between the edges and pressure was applied uniformly from the inside by forcing water into the space between the panels. A mercury column and pressure gauge were used to obtain pressure readings, and a mercury *(Continued on page 352)*

PRESSURES AND DEFLECTIONS OF ¼-IN PLYWOOD PANELS NAILED AND GLUED TO A 2x4 OAK FRAME AT ALL FOUR EDGES

Size of panel	4x4 ft	2x2 ft	2x2 ft
Water pressure per sq in, lb	Deflection, in	Deflection, in	Deflection, in
1	0.688	.145	
2	1.415	.445	
3	1.655	.485	
4	1.780	.519	.416
6	Failure*	.709	.601
8		1.335	.782
10		Failure†	Failure†

*Leaks occurred at defects and knots in the outer ply.

†The center ply, or core, broke or failed next to the frame. In no case did the glue joint fail.

M. A. SHARP is head, agricultural engineering department, University of Tennessee.

This picture shows a plywood panel under pressure test

Teamwork...

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The urgent necessity of war has taught us many useful things . . . new methods, greater capacity. It also has shown us the supreme importance of teamwork, and the irreplaceable value of experience.

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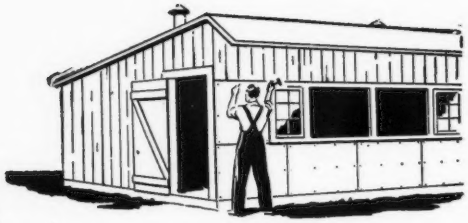

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Tests of Plywood Panels

(Continued from page 350)

column actuated by a plunger was used in addition to a common rule for measuring deflection. The accompanying illustration shows a panel under test and that the first failures may be expected around imperfections in the outside layer of the plywood. The accompanying table gives detailed information regarding pressure-deflection raios, which indicate that plywood has ample strength for this type of construction.

Dairy Engineering

DURING the past year the A.S.A.E. Committee on Dairy Engineering has studied four principal problems in dairy engineering as follows: (1) Modern practices in milk transportation, (2) status of mechanical refrigeration on small dairy farms, (3) possibilities of mechanizing the dairy barn, and (4) current problems in dairy engineering.

R. L. Perry reports that considerable progress is being made in the bulk handling of milk direct from farms in the southern California area. Problems of accurate sampling and weighing appear to be of most concern with this method.

Mechanical refrigeration for cooling milk on the farm is receiving a great deal of attention from health authorities, farmers, and manufacturers. Intensive study and development work is being carried on by a considerable number of large concerns with the thought of being able to supply an improved unit for farm use after the war. Most of the coolers appear to be of the tank type; however, one new type which cools the milk by means of a direct expansion coil in a ten-gallon can has been developed.

S. A. Witzel reports that several practical mechanical barn cleaners are being used successfully in Wisconsin at the present time, and that by pushing an electrical switch button the cleaning operation is accomplished efficiently and with no hand labor. This development deserves further study along with other modern ideas for mechanizing the dairy barn.

Current problems in dairy engineering include principally how to make the best of the shortage of trained help; however, looking at the broad picture, it appears that in the postwar period the emphasis is going to be on reduced costs, labor saving, and increased sanitation. Some of the specific problems are the more efficient methods of cooling milk on the farm and collecting and transporting milk from farm to factory, and the mechanization of dairy barns to eliminate hand labor. There appears to be a real need for continued work on these problems, and it is suggested that the work of the Committee be continued along the same general lines with more emphasis on publication of results as soon as they are available.

A report of the Committee on Dairy Engineering of the American Society of Agricultural Engineers for 1943-44 — A. W. Farrall (chairman), J. E. Nicholas, R. L. Perry, S. A. Witzel, and John Strait.

The Engineering Profession Tomorrow

THE engineering profession tomorrow will be largely what engineering education today makes it. The policies of industry, government, and state boards of course will have their influence. Nevertheless, the character of the profession — the height of its purpose, the extent to which its members live up to its ideals, the nature of its standards — must rest fundamentally upon individual convictions, individual attitudes, individual intellectual power; and these qualities are largely molded in college. The form of the mold is determined by the teachers and administrative officers of engineering colleges. If the profession is to be brought up to the level which America needs, and is to receive the recognition which it deserves, the educators must bring it there. This is a pointed responsibility that, in light of lessons of the war, weighs upon us as it has not weighed upon any previous generation; it is a challenge we must accept. — Robert E. Doherty, president, Carnegie Institute of Technology, in his presidential address at the 52nd annual meeting of the Society for the Promotion of Engineering Education, June, 1944.

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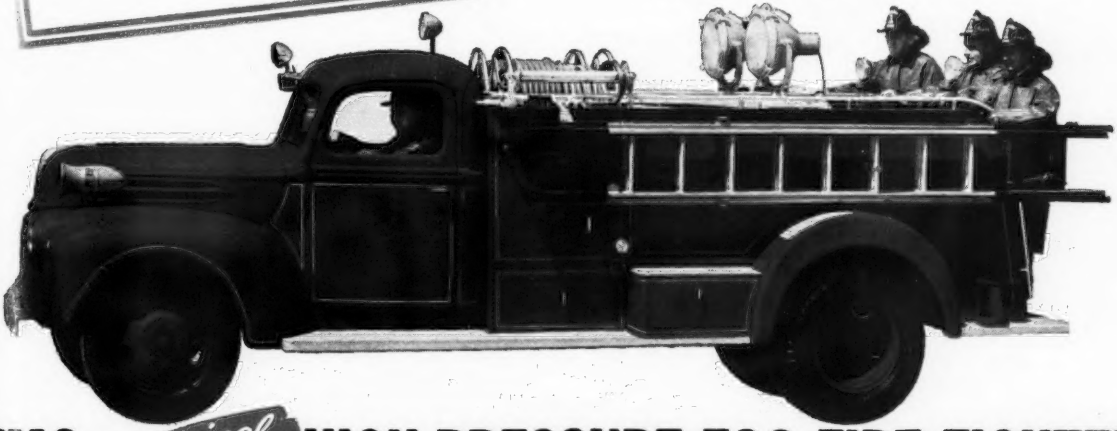


FMC *Original* HIGH-PRESSURE FOG FIRE FIGHTER

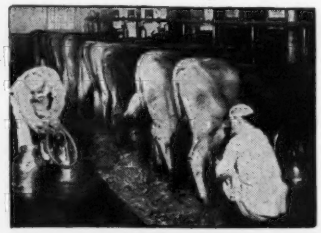
CAN BE MOUNTED ON MOST STANDARD TRUCK CHASSIS

FOOD MACHINERY CORPORATION

JOHN BEAN MFG. CO., 700 HAZEL ST., LANSING 4, MICH. • BEAN-CUTLER DIVISION, 400 JULIAN ST., SAN JOSE, CALIF.

BUILDERS OF BEAN HIGH-PRESSURE PUMPS FOR OVER 60 YEARS

ONE WORD
FROM *You* CAN HELP..

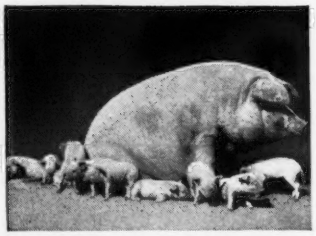


PRODUCE MORE MILK

Feed costs drop and winter milk production jumps when dairy barns are insulated with ZONOLITE—Granular Fill for walls and ceilings and Insulating Concrete for floors.

PRODUCE MORE EGGS AND CHICKS

Poultry houses insulated with Zonolite reduce feed bills substantially by conserving birds' body warmth—which also promotes egg production in laying hens and weight increases in growing birds.



CUT PIG LOSSES

Warm, dry Zonolite Insulating Concrete floors are quickly and easily laid over old, cold ones. Most farmers can readily do the work themselves—cut farrowing losses substantially.

SAVE UP TO 40% OF FUEL USED IN HOME

A few hours' work will insulate their attic for Zonolite simply *pours* into place as easily as pouring popcorn from a bag. Fuel conservation is a patriotic duty, today!

THAT ONE WORD IS.. ZONOLITE

Zonolite—the mineral insulation of a hundred uses—comes in 3 forms: Granular Fill, Insulating Concrete Aggregate, Insulating Plaster Aggregate. All three are 100% FIREPROOF—even 2400 degrees F. does not burn Zonolite! But for full facts about this amazing insulation and its multitude of uses, mail coupon.

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Dept. AE9 • 135 South La Salle Street • Chicago 3, Illinois

ZONOLITE INSULATION
Permanent as the Earth Itself

Universal Zonolite Insulation Co.
Dept. AE9, 135 S. La Salle St.
Chicago 3, Illinois

Please mail me complete information about all 3 forms of ZONOLITE. Include, without obligation, WORK SHEETS showing typical farm uses.

NAME.....

ADDRESS.....

CITY.....STATE.....

NEWS SECTION

A.S.A.E. Meetings Calendar

September 26 and 27 — North Atlantic Section, Commodore Hotel, New York.

A.S.A.E. Fall Meeting Cancelled

SOLELY in response to the urgent appeal of the Office of Defense Transportation that all organization gatherings scheduled for the remaining months of 1944 be cancelled, the usual Fall Meeting of the American Society of Agricultural Engineers scheduled to be held at Chicago during the second week of December has been called off for this year. This action was taken to help relieve the critical transportation situation, and not because it was felt the meeting was not needed, for members of the Society feel the need for their meeting more keenly this year than ever before.

In lieu of the Fall Meeting, the Council and the Meetings Committee of the Society will meet during the week in which the meeting was scheduled, and certain conferences or round-table group meetings will be held to give attention to the more urgent problems confronting the agricultural engineering profession, and to plan future activities in connection therewith.

A.S.A.E. North Atlantic Section to Meet in New York

THE North Atlantic Section of the American Society of Agricultural Engineers will hold its annual meeting September 26 and 27 at the Commodore Hotel in New York City. All members of the Society whether resident in the territory of the section or in other parts of the country will be welcome to attend the meeting. The Section officers' invitation includes also non-members of the Society who have a particular interest in the program to be presented.

As this issue goes to press, copy for the program has not been received from Section officers, but printed copies will be mailed on request to either Section Secretary Ralph J. Bugbee, 121 West Street, Rutland, Vt., or from Society headquarters at St. Joseph, Michigan.

Postwar Tractors, Fuels, and Steels on S.A.E. Program

AN engineering preview of postwar tractors, the steels of which they are made, the fuels they will use, and their pertinent design details will be presented on the program of the national tractor meeting of the Society of Automotive Engineers to be held at the Schroeder Hotel in Milwaukee, September 13 and 14.

The forenoon session of September 13 will feature a paper on the design of gear teeth to be presented by Fred Bohle of the Illinois Tool Co. Prepared and informal discussions will follow this paper.

The subject of fuel will occupy the entire afternoon session, the discussion of which will be centered around a paper on fuel requirements for tractors by A. T. Colwell of Thompson Products, Inc.

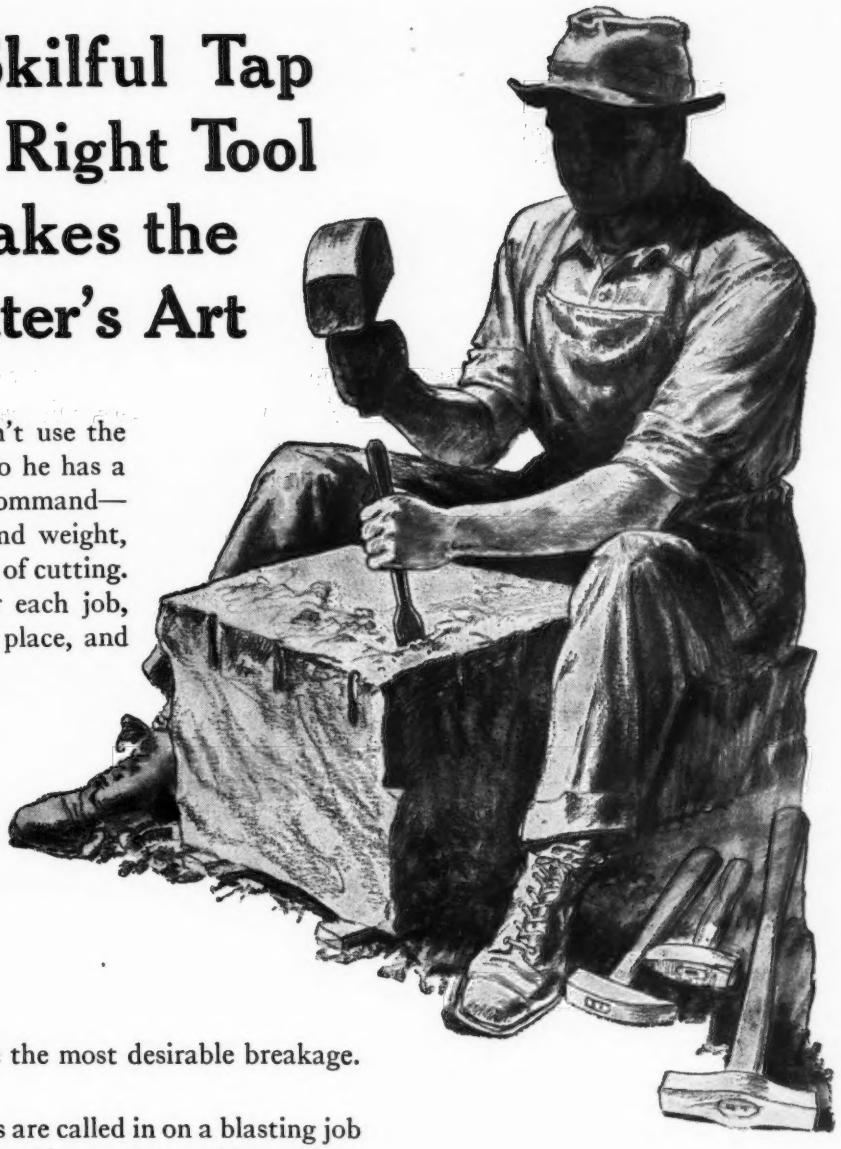
The application of gasoline injection to tractor engines is the subject of a paper by H. O. Hill of American Bosch Corp., which will feature the forenoon session of September 14. The afternoon session will be headed up by a paper on automotive steels from the engineering viewpoint, to be presented by H. B. Knowlton of the International Harvester Co.

The annual tractor dinner of the S.A.E. Tractor and Farm Machinery Engineering Activity will be held the evening of September 14, with O. R. Schoenrock of the J. I. Case Co. as chairman and C. E. Frudden of Allis-Chalmers Mfg. Co. as toastmaster. Feature addresses following the dinner will be on the subject of tractors of tomorrow by W. S. James of The Studebaker Corp., president of S.A.E., and on agriculture's postwar opportunities by Wheeler McMillen, editor-in-chief of "Farm Journal".

Dickerson Made A.S.A.E. Life Fellow

THE Council of the American Society of Agricultural Engineers recently elected I. W. Dickerson a Life Fellow of the Society. Mr. Dickerson joined the Society in 1910, has been a member without interruption ever since, and served a period as Secretary during the early years of Society history. For many years Mr. Dickerson has rendered a highly practical service as agricultural engineering editor of several farm papers, including "American Agriculturist", "The Farmer", "Farmer-Stockman", "Montana Farmer", "Poultry Item", "Wallace's Farmer", "Iowa Homestead", and "Western Farm Life".

It's the Skilful Tap With the Right Tool That Makes the Stonecutter's Art



THE stonecutter doesn't use the same hammer on all jobs. So he has a number of hammers at his command—each of a different shape and weight, each made for a specific type of cutting. Using the *right* hammer for each job, hitting in exactly the right place, and with just the right force, the stone is cut precisely as the stonecutter wants it.

In blasting likewise you cannot use the same tool for every job and get good results each time. It takes the *right* explosive, used by the right method—with the right force, at the right place—to produce the most desirable breakage.

When Atlas Representatives are called in on a blasting job they apply synergistic* thinking to the problem. They study every detail, swap ideas with the blasting men. From this comes a specific recommendation: The *one explosive*, the *one blasting method*, that will produce the utmost in fragmentation.

***Synergism:** *The force that produces "2 + 2 = 5" results when you and we get together and really "click."*

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Personals of A.S.A.E. Members

B. P. Hess, for many years connected with the rural electrification activity of the Westinghouse Electric and Manufacturing Company, has been transferred to the general mills section, industry department, East Pittsburgh. In his new work, Mr. Hess will keep farm equipment manufacturers informed of the latest developments in electric drive and control. Mr. Hess joined Westinghouse in 1931, is a graduate of Ohio State University in both agriculture and electrical engineering, and is currently a member of the Council of A.S.A.E.

A. Kirk Crawford, formerly instructor in agricultural engineering at the Northwest School and Station of the University of Minnesota at Crookston and more recently engaged in instructional work in electrical engineering in connection with the war effort at the University in Minneapolis, recently accepted a position in the engineering division of the Weyerhaeuser Sales Company at St. Paul.

James W. Culpepper has resigned as assistant county agricultural agent of Lowndes County, Alabama, to accept a position as junior agricultural engineer with the Tennessee Valley Authority at Knoxville, Tenn., where he will be engaged in research and development work.

Orsen W. Israelsen, research professor of irrigation and drainage, Utah Agricultural Experiment Station, and collaborator with the U. S. Department of Agriculture, is one of the authors of Technical Bulletin 313, entitled "Canal Lining Experiments in the Delta Area, Utah", recently issued by the Utah station in cooperation with the division of irrigation, U. S. Soil Conservation Service.

Lawrence H. Schoenleber, formerly a member of the agricultural engineering staff of Kansas State College, recently accepted a position as an engineer with the J. I. Case Co., and will be located at Racine, Wis. He will be engaged in testing, research, design work, etc.

Paul W. Silvey, until recently advertising manager of the Brower Manufacturing Company, Quincy, Ill., is now employed as general manager of the Parkin Hatchery, at Shawnee, Okla.

Charles G. Snyder, Jr., has resigned as instructor in agricultural engineering at the University of Minnesota to accept a position as field enginer in the technical service bureau of the Universal Atlas Cement Co., Chicago.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Carl L. Cue, director and purchaser of farm supplies, United Cooperatives, Inc., 510 W. Ely St., Alliance, Ohio.

Sherwood S. DeForest, engineering officer, U. S. Army Air Force. (Mail) 3660 LeBlond Ave., Cincinnati, Ohio.

Norman A. Evans, Private, infantry, USA. (Mail) Spearfish, S.D.

George M. Eveleth, chief engineer, J. I. Case Co. (Mail) Rock Island, Ill.

Seward H. Foote, Jr., agricultural field representative, Portland Cement Assn. (Mail) Georgetown, N. Y.

Clarke D. Pease, chief engineer, New England Industrial Development Corp., Chamber of Commerce, Boston, Mass. (Mail) University Club.

W. R. Persons, farm sales and service, The Lincoln Electric Co., P.O. Box 5758, Cleveland, Ohio.

F. Frank Schwilk, vice-president and general sales manager, automotive division, Continental Motors Corp., Muskegon, Mich.

C. E. Stewart, consulting irrigation engineer, 7658 Calumet Ave., Chicago 19, Ill.

Harold H. Todd, equipment manager, Merrimack Farmers' Exch., Inc. (Mail) 9 Green St., Concord, N. H.

J. Vincent Webster, engineer, David Bradley Mfg. Works. (Mail) 392 S. Chicago Ave., Kankakee, Ill.

LESS FUEL THIS WINTER ?

Farmers can be comfortable anyway!

Now's the time to install
MASONITE* CELL-U-BLANKET

Even if heating fuels should be a little harder to get this winter, farmers can keep their homes comfortable—by merely nailing or stapling Masonite Cell-U-Blanket insulation to roof rafters or ceiling joists.

This, the latest word in home insulation, comes in rolls and convenient lengths, and is semi-rigid yet light in weight.

Yet for all its easy handling, Cell-U-Blanket is unusually efficient. Wind-proof. Waterproof. It provides a positive vapor barrier. It is permanent and will not shrink, sag or settle. Prevents high heat losses. Makes the whole house snug and warm.

Masonite Corporation engineers will be glad to consult with you on the application of Cell-U-Blanket to farm homes and buildings.

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MASONITE CELL-U-BLANKET

A NEW AND MORE EFFICIENT INSULATION • SOLD BY LUMBER DEALERS

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Please send me a FREE sample and full details about farm applications of Masonite Cell-U-Blanket.

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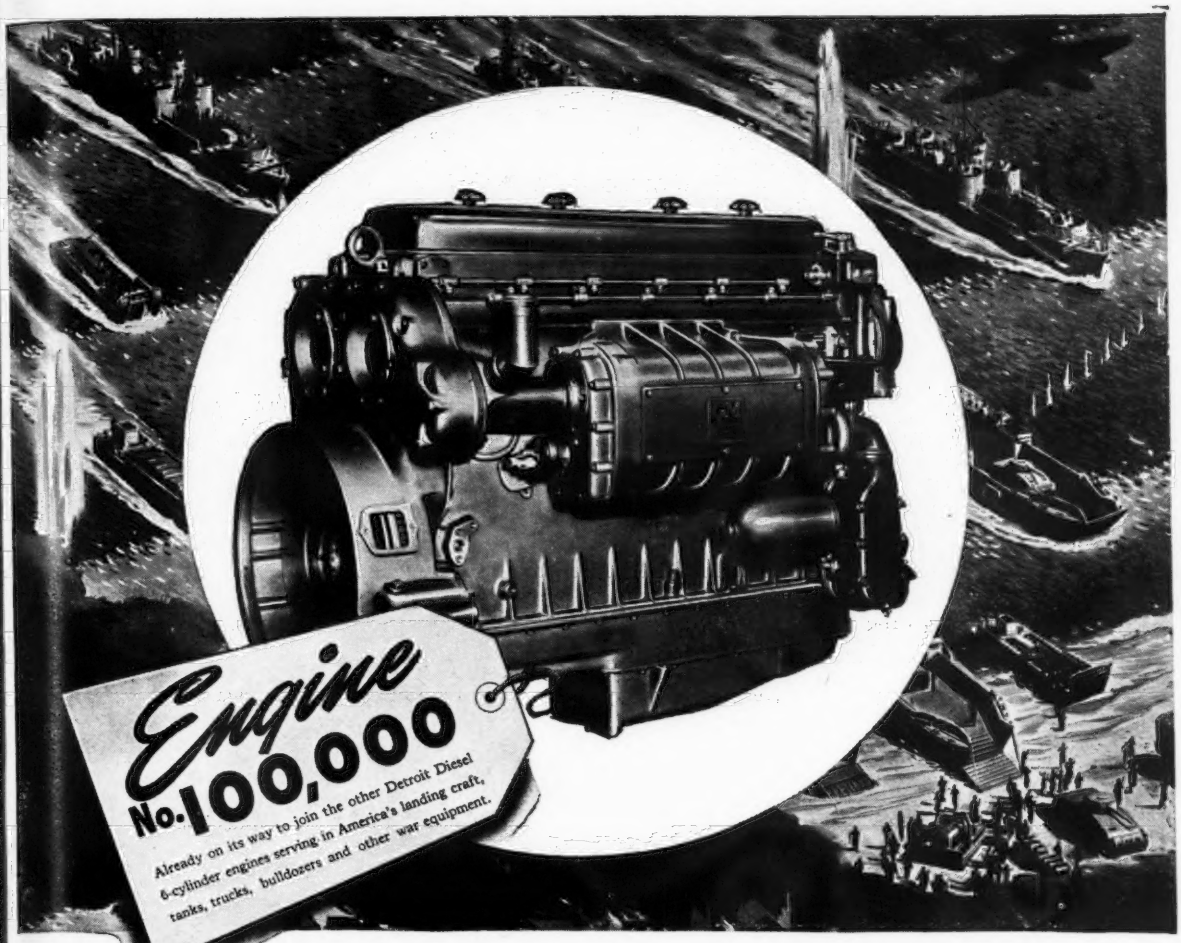
*R. F. D.*_____ *City*_____ *State*_____

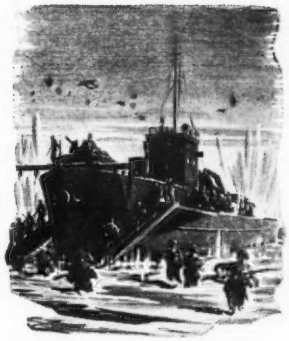

Engine
No. 100,000
Already on its way to join the other Detroit Diesel 6-cylinder engines serving in America's landing craft, tanks, trucks, bulldozers and other war equipment.

10 DIVISIONS OF FIGHTING ENGINES

MONTHS ago the Detroit Diesel Engine Division of General Motors sent engine No. 100,000 off the production line to its war job. Many more have followed since. Measured as men, more than ten divisions of these six-cylinder Diesels are actively in the fight. They're in landing craft helping to crack Fortress Europe and to cut the Nips' string of islands. They're in tanks, trucks, bulldozers and all kinds of other equipment. The reasons are, these Diesels are tough and dependable. They're easy to maintain. They burn inexpensive fuel oil.

They have been tried and proved in all sorts of war jobs on every battle front. And they've been found good.

With the coming of peace these engines will be available for all the applications where America will need reliable, low-cost power.



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ENGINES . . 150 to 2000 H. P. . . CLEVELAND DIESEL ENGINE DIVISION, Cleveland 11, Ohio

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There's more to babbitting connecting rod bearings than simply applying the metal. Not only must the work be expertly done, but it is important that frequent detailed chemical analyses be made of materials in order to provide a dependable safeguard against inferior quality bearing metal, and to assure constant uniformity.

Wisconsin Engine connecting rod bearings are babbitted in our own plant, under our own complete control. A careful check is maintained to make sure that the metal is always what it *should* be and that it is applied *the way it should be*. This helps to make a better engine . . . designed to give better service on your equipment.

Most H.P. per pound

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

RILCO *Laminated* WOOD RAFTERS in farm construction

Write for Your Copy of this New Book

● A fair sized engineering department, has worked pretty steadily for over a year to prepare this detailed and illustrated presentation of Rilco laminated wood rafter arches and Rilco pre-fabricated buildings.

The new Rilco book gives complete engineering, estimating and erection data and shows the many different types of Rilco rafter arches available for one and two story barns, machine sheds, corn cribs and granaries, poultry, hog and utility buildings.

Rilco laminated wood rafter arches are engineered for wind, snow and concentrated loads. They are continuous framing members running from foundation to roof ridge. They are factory-made to accurate patterns, properly drilled and trimmed for sill and ridge connections and delivered ready for speedy erection. They save time, material and labor.

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Member A.S.A.E. Suite 4300, Board of Trade Bldg.,
Telephone: Wabash 1558 141 W. Jackson Blvd., Chicago 4, Ill.

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any Notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

FARM STRUCTURES MAN wanted by large company for expanding program in prefabricated farm buildings and components. Excellent opportunity for man qualified in functional phase of design and promotion. Replies should indicate scope of training and experience. Confidential. PO-167

SALES ENGINEER wanted for permanent position with small company producing well-accepted building material products. Substantial base salary, better than average proposition for man with liking for sales work and knowledge of building construction. Give full information on past experience and earnings expected. PO-166

AGRICULTURAL PRODUCT ENGINEER wanted for mechanical designing and development of corn pickers, combines, and other harvesting machines. Permanent position with old well-established midwest manufacturer with national distribution. Located in fine city with adequate housing and educational facilities. Big postwar farm market assures future. Salary open. Good opportunity for advancement. Write experience, qualifications, draft status, and other particulars in your letter. PO-165

ENGINEERING AIDS needed in federal agencies. Persons to perform subprofessional engineering work in civil, topographic, photogrammetric, mechanical, and other branches of engineering are being sought to fill federal jobs in Washington, D.C., and in other parts of the country. The salaries range from $1752 to $3163 a year, including overtime pay. Appointments will be made in the Geological Survey, Department of the Interior, Coast and Geodetic Survey, Department of Commerce, and Department of Agriculture, and application forms may be secured at first and second-class post offices or direct from the U. S. Civil Service Commission, Washington 25, D. C., or from the Commissions's regional offices.

AGRICULTURAL ENGINEER wanted by a well-known national organization to engage in sales promotion work on farm buildings, preferably someone in his early thirties with good engineering training and farm background and with plenty of initiative and ingenuity. Special training in farm buildings would be helpful to person selected. Discharged service men will receive special consideration. Write giving full details as to education, experience, etc. PO-164

SALES ENGINEERS, preferably 32 to 38 years of age, with college education in engineering and with sales experience, are wanted by a large national manufacturing organization to engage in the sale of farm buildings through dealers. While a postwar project, qualified applicants will be interviewed now. Special consideration will be given discharged service men who have qualifications sought. Write giving full particulars as to education, ex-

(Continued on page 360)

● *Self-Propelled Combine by* Massey-Harris Co., Inc.

Combine for rice harvest

SKF

BALL AND ROLLER BEARINGS

A rice machine traveling over rough ground, levees and ditches takes a terrific beating. So do its SKF Bearings on vital turning parts. While this No. 21 Combine operates almost continuously under difficult traction conditions in mud and heavy wet rice stubble, SKF's roll smoothly and continuously, helping this machine to revolutionize rice harvesting . . . to cut costs to a fraction of previous figures. The more SKF's on farming equipment, the greater the harvest. 5551

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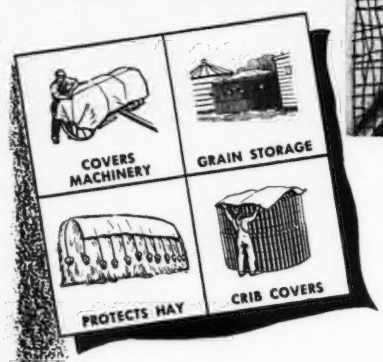

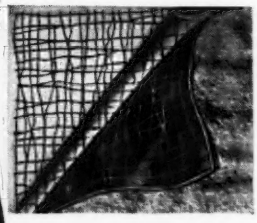

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EMPLOYMENT BULLETIN

INSTRUCTOR in farm machinery and farm motors wanted by a state agricultural school of secondary vocational grade, for six months beginning October 1st. Write A. C. Heine, head, agricultural engineering dept., West Central School and Station, Morris, Minn.

FARM EQUIPMENT ENGINEERS. National merchandising organization planning large farm equipment program has openings for senior and junior design engineers. Write experience, draft status, salary expected. Replies confidential. PO-155

ENGINEER interested in drainage research wanted. Southern state with large acreage needing drainage plans to begin intensive research program. First letter should give training, experience and references. PO-153

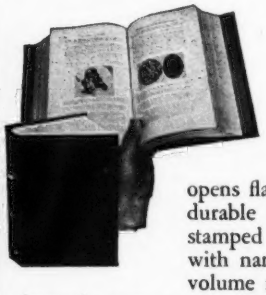
POSITIONS WANTED

AGRICULTURAL ENGINEER available. Six years' experience in rural electrification with private power company and government power project; experience in educational and research phases of the work. Two years' experience in farm management with state institution. Well acquainted with personnel of the land-grant colleges in midwest and southern states. Two years' experience as mechanical engineer and plant supervisor for large industrial concern. B. S. degree from a Midwest university. Age 32, health excellent, married. PW-363

AGRICULTURAL ENGINEER with a B. S. degree in agricultural engineering from an eastern college is available for employment. Experience in soil conservation, drainage, and use of explosives in land drainage and land clearing; farm reared with experience and knowledge of the operation, care, and adjustment of farm machinery and equipment, also wood-working equipment and farm building construction. Age 38, married, two children. Would like position in teaching, research, or extension work. PW-362

AGRICULTURAL ENGINEER with a B. S. degree in agricultural engineering from a midwest college and training course in management, operating and buying with mail-order firm. Two years' experience in farm building appraisal, inspection and fire prevention. Present position, purchasing and planning of aircraft parts. Age, 27 years; married with two children; draft status, 2B. Would like position in development and promotion of farm buildings and equipment or in purchasing or production work in a factory manufacturing agricultural equipment. PW-361

A Handsome, Permanent Binder *for* AGRICULTURAL ENGINEERING



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the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

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With blue ground for Fellows and Members—furnished either in pin with safety clasp or lapel button—$2.00 each.

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Send orders to ASAE, St. Joseph, Michigan.